KNOWLEDGE
AN ILLUSTRATED
MAGAZINE OF SCIENCE
SIMPLY WORDED—EXACTLY DESCRIBED

LONDON: JANUARY 1, 1889.

CONTENTS.

	PAGE
Hazel and Filbert. By Grant Allen	49
The Chemistry of Soap. By W. Mattieu Williams, F.C.S, F.R.A.S.	51
Meal and Tabby Moths. By E. A. Butler	53
Variable Stars. By W. H. S. Monck, M.A., F.R.A.S.	55
A Photo-Geological Trip to the South Stacks. By W. Jerome Harrison, F.G.S.	57
Automatic Recording Instruments of the Lick Observatory	58
Notes on the Spotted Salamander. By A. J. Field	60
The Health of London. By Alex. B. Macdowall, M.A.	61
On Some Strange Feats of Calculating Boys. By the late R. A. Proctor	63
Letters: Lord Grimthorpe, W. J. Atkinson, A. Bovell, A Farmer, and H. J. Madge	64
How Comets come to us. By A. Cowper Ranyard	66
Notes	67
The Great Nebula in the Pleiades. By A. Cowper Ranyard	68
The Face of the Sky for January. By Herbert Sadler, F.R.A.S.	70
Our Chess Column. By "Mephisto"	71
Our Whist Column. By W. Montagu Gattie	71

HAZEL AND FILBERT.

By Grant Allen.

IN the very youngest days of the young new year, if you look closely at the bare boughs of a hedgerow hazel bush, you will see them covered all over with little oblong pendent catkins, unopened or unexpanded as yet, and fitted close with hard small scales, that lap over one another in serried rows, like tiles on a housetop. The catkins are produced long beforehand in the autumn months, and they then lie by over the winter, as it were in a dormant state, waiting for the first warm days of spring to expand and blossom in their fluffy fashion. For spring always begins in autumn, biologically speaking: the buds and flowers are laid up ready, in anticipation of the warmer season; the plant prepares itself, both for its winter sleep and for its spring awakening, in the last few weeks of the failing summer.

Why is this? Well, when one comes to think of it, it is clear that no tree or shrub can really and truly "blossom early." When it seems to do so, what actually happens is rather a deferred than a hurried blooming. Instead of flowering late in autumn, the plant lays by its material over the winter, and the buds open in the early springtide.

For the green leaves, which have to do all the real work of the plant—its mouths and stomachs—must lay by quantities of starches and protoplasm before the flower-buds can be produced at all. Now, here we have a practical difficulty for many plants to meet, especially in the case of large and leafy trees and bushes. For while, on the one hand, there must be leaves to supply material for the flowers; on the other hand, the flowers themselves are apt to be hidden by the foliage and so rendered useless. If they are showy flowers of the insect-fertilised type, which lay themselves out to attract winged visitors who will carry the pollen from head to head, the leaves serve to mask and overshadow them. If they are inconspicuous flowers of the wind-fertilised type, the leaves get in the way of the floating pollen and prevent a great deal of it from reaching the sensitive surface or stigma of the female blossoms.

Once more, if the plant is one which has to ripen a large fruit, like an apple, or peach, or plum, or hazel-nut, it is clear that if it has to get all the work done within a single season there will hardly be time for all the necessary processes to get themselves completed within the limits of our short northern summer. If the apple-tree or the hazel, for example, had first to put forth leaves and collect material for the year's blossom, and then to flower, in the same year, there would be no time left for the apples and the filberts

LEAVES AND LEAF-BUDS AND MALE AND FEMALE CATKINS OF HAZEL.
A. Male. B. Female.

to ripen properly before the frosts of December were well upon us.

Under these circumstances, a great many trees in temperate climates have hit upon a simple and sensible device for combining all possible advantages in a single plan. All the summer long they collect material, part of which they store up in the inner bark for next year's use, and with part of which, as autumn comes on, they make up buds or catkins for the spring flowering. Thus they put off their blossoming till the second season, so as to do it more effectively when they once begin, and have longer time to ripen their fruits throughout the entire summer.

This plan enables the tree to start well in the early spring, and to take advantage of the first bright days of sunshine, before the leaves have come out to get in the way of the

flowers or their useful visitors. The apple, peach, plum, and apricot are good examples of this method of blooming: so, even more markedly, are the flowering almond, the Daphne Mezereon, and the Pyrus Japonica. In these cases, the bees which visit the blossoms and set the fruit are attracted from afar by the brilliant show of the petals on the clustered branches; and, as there are always bees about on every sunny day the year round, the tree ensures getting fertilised early, and so having plenty of time and opportunity to ripen its fruit through the long summer. Later in the year, when annuals have begun to bloom profusely, there would be far more competition for the insect favours.

To catkin-bearing trees, however, the necessity for such an early blooming (as we call it) is still greater and more pressing, for catkins are almost always wind-fertilised, and if they waited till the leaves were out, the pollen would get wasted among the covering foliage, and very likely the seeds and fruits would never get fertilised at all, except by the merest accident. Hence all catkin-bearers produce their catkins in the autumn months, and leave them to blossom as early as convenient in the windy spring, when they stand the best possible chance of the breeze carrying the pollen to its proper receptacle.

A flower-bud, however, is a very tender and delicate living thing, containing protoplasm and other vital stuffs that might readily be injured by the cold of winter. To prevent such a misfortune, therefore, the catkins are protected by close-fitting scales, so arranged as to be very bad conductors of heat, and enclosed within this imbricated coat of mail the actual flowers survive through the winter without suffering in any way from snow or frost. But that they are there all the same from the very beginning, though folded up so as to be almost invisible, you can easily convince yourself by opening a catkin in the depth of winter, when you will find the little flowers inside all fully formed, with stamens already easily distinguishable, and the material for the pollen laid up beforehand as a rich protoplasmic juice within them.

With the first spring weather the hazel begins to blossom, being almost the first, if not the very first, of our English trees to brave the chilly winds of declining winter.

FEMALE CATKIN.
(Enlarged.)

MALE CATKIN.
(Natural Size.)

As soon as it does so, you will see that its catkins are of two kinds, or to speak more correctly, it has two sorts of flowers, one of which nobody would call a catkin except the most formal and technical of botanists. Let us begin by examining in detail the catkin which everybody can see is a catkin; and then let us go on to pick to pieces the little stumpy red-tasselled knob which is only a catkin by botanical courtesy.

The conspicuous hanging catkins consist of the male or pollen-bearing flowers, here clustered together in long pendent groups, and each enclosed in the leafy scale which harboured it so well through the long winter. The flowers themselves are flowers reduced to their very simplest elements, for they consist only of eight stamens, without any petals, calyx, or other attractive organs. In the hazel, in fact, the degradation suffered by most wind-fertilised blossoms has almost reached a point beyond which any further simplification is impossible. Originally, we can hardly doubt, the ancestors of the catkin-bearing trees had flowers with showy corollas and protective calyces, much like the horse-chestnuts and apple trees at the present day. But as they took to the habit of wind-fertilisation, they gradually lost their petals, and then their calyces, till at last in the hazel the flowers have been reduced to a point of simplicity beyond which it would hardly be possible to go. And of the various stages in this downward process, we have abundant examples still left us in nature.

The true chestnut, for instance, has male flowers with five or six dwarfed petals, and female flowers with what I take to be a cup-shaped and five-lobed calyx. In the birch, the male flowers are still quite flower-like and distinct, with five or six petals or sepals; while the female flowers have lost almost all sign of the original calyx or corolla. But in the hazel, the calyx and corolla are gone in both kinds of flowers, and nothing remains but a covering bract, at the base of which the stamens are inserted.

I have called this process a degradation, and so it is from the point of view of floral architecture; the flower has become simpler and less varied in its parts. But from the point of view of adaptation to the particular needs of the tree it is rather an advance, for the tree wants to be

FEMALE FLORET.
(Enlarged.)

MALE FLORET.
(Enlarged.)

fertilised by the wind, and therefore has got rid of the needless corolla, and has devoted all its strength to producing flowers fitted to its new habit. The willows are in this respect a very interesting group of catkin-bearing trees; for they are catkin-bearers which, having gone once through all these stages, and having got rid of their attractiveness in order to become wind-fertilised, have once more taken to the abandoned practice of insect-fertilisation, and so have developed handsome, fluffy, yellow catkins and rich honey-glands in order to attract the visiting bees. They had lost their petals long before, and now, to supply the place of those coloured organs, they have recourse to brightly-tinted stamens: but how well these serve their purpose anybody can see who listens on a bright spring morning to the constant hum that buzzes round the branches of a flowering willow.

The hazel, however, got once for all to the wind-fertilised stage, and then stopped there. Its little stamens, freely balanced on their short filaments, shake out showers of pollen at the slightest puff of wind, as you can observe for yourself by standing near the bush, or still better by shaking a branch with a gentle touch. The pollen then falls upon the nearest female flowers, and fertilises them at once with its life-giving powder.

As for the female flowers, they grow in funny little close red knobs on all the branches, looking much more like leaf-buds to the untrained eye than like anything worth calling in the popular sense a catkin. All that you can see when

you first examine them is just a bud with a lot of tiny red tassel-like fibres protruding from the summit. But you must begin unrolling one of these buds, scale by scale, very patiently, and then you will see what the female flowers are really driving at.

The first few outer and lower scales of the bud are quite empty. They are merely the protective covering that kept the real flowers inside warm and snug through the frosts of January. The inner scales, however, have each in their axil a tiny flower of a very curious and instructive sort. It consists, first, of a kind of tubular calyx, the remnant of the old floral envelopes of its ancestral type; and inside that again of a single ovary, the undeveloped filbert in its baby stage. From the summit of the ovary project two red styles, which rise above the bud and project outside, so as to form in the mass the little red tassel. On these the pollen falls when the tree is shaken by the wind; and then the pollen-tubes penetrate the styles, and quicken the wee kernel that lies, almost microscopic, in the centre of the yet undeveloped nut.

As soon as fertilisation has thus taken place, the nut begins at once to swell and ripen. The ovary itself grows into shell and kernel; the little cup shaped calyx grows outside it into the husk or protective covering of the filbert. And we see here once more how duly every part is utilised in the final growth. The male catkins have done their work; they fall off and die. But in the female catkins, the ovule or seed (which we call the kernel) grows large and rich, well-stored with valuable oils and starches, to feed the young hazel tree on its first entry into an unkindly world. The fruit proper, or shell which surrounds the kernel or seed, grows hard and strong, and has to protect this vital organ as far as possible from the attacks of squirrels, dormice, and other dangerous enemies. And the outer husk or envelope invests itself in sharp and disagreeable hairs, to wound the tender noses of would-be intruders, or the paws and hands of unwary pickers. In the filbert everything is arranged for defence, because the part of the plant which animals wish to eat—the seed itself—is the very part which of all others the plant least desires to have eaten. It defends its young with all the tenacity and determination of a tigress; it redoubles precautions against the chance of its precious seedlings being discovered and devoured. For this reason the filberts are green in their husks on the green tree, but brown in the shell when they fall out at last on the bare brown soil of the thicket beneath.

CLUSTER OF RIPE HAZEL-NUTS.

NICOTINE AS A DISINFECTANT.

Mr. V. Tassinari's experiments with the germicidal properties of nicotine, in the shape of tobacco smoke, seem to point the way to a new disinfectant. A piece of linen that had been dipped into a solution containing numerous microbes was exposed to the fumes of cigarettes or a cigar. The rag was then immersed in a vessel containing a liquid known to be favourable to the multiplication of the microbes. Upon repeated trials with various micro-organisms, contrasted the while with similarly prepared rags which had not been fumigated, showed that the smoke had greatly, and in some cases altogether, destroyed the life of the organisms.

THE CHEMISTRY OF SOAP.

BY W. MATTIEU WILLIAMS, F.C.S., F.R.A.S.

ONE of the classics of inductive research is the celebrated essay on Fats, an early work of the centenarian Chevreul, who proudly yet modestly and justly styles himself the patriarch of students; for he is a student still, and will be until his long life is closed. This work laid the foundation of a very important branch of theoretical organic chemistry, and has yielded a rich harvest of those useful practical results which Bacon predicted would follow from the general and systematic adoption of the inductive method of dealing with facts, as compared with the barren outcome of scholastic disputation.

Everybody now knows that soap is made by heating fat or oil of some kind with soda or potash, and before the publication of Chevreul's researches, the best chemists of the day regarded the soap thus formed as simply due to a combination of the fat or oil, as such, with the alkali—a very simple and natural inference. It would be too long a story to tell the history of the correction of this mistake, and I must therefore briefly state the broad results of the laborious researches which effected it.

Speaking generally, they have taught us that ordinary oils and fats are compounds of what has been named a fatty acid with glycerine. I should explain that in modern chemistry acidity does not mean sourness; an acid may be sour as a rose may be red, but sourness is no more a necessary property of acids than redness of roses. A flint is tasteless, although nearly pure silicic acid. The fatty acids, like the flint, are tasteless, or nearly so and certainly are not at all sour. Broadly and simply defined, an acid is a compound which combines with another class of compounds that are called bases to form new compounds called "salts," and reciprocally, a base may be defined as a compound that combines with acids with the same result. The alkalis (soda, potash, ammonia, &c.) are very strong bases, just as sulphuric, nitric, and hydrochloric acids are very strong acids. It usually happens that when a weak acid is combined with a base, a stronger acid will overpower it and take away its base, leaving the acid "out in the cold," and *vice versâ*, strong bases similarly oppress their weaker basic brethren.

I may add, in passing, that further generalisations of modern chemistry have connected the fatty acids with ethers; common fats are described as ethers of glycerine, and thus mutton suet, olive oil, &c., have been brought into what some folks would regard as bad company, with alcohol, and are even described as "trivalent alcohols," and innocent glycerine as "the alcoholic or basic constituent of the fats." As KNOWLEDGE is not a scientific balloon, I shall not carry my readers into chemical cloudland, but we will travel together and in company with the venerable Chevreul on the terra firma of old-fashioned fatty acids and bases.

All these fatty acids are very weak acids, and their common associate, the glycerine, is a very weak base, therefore it is not at all difficult to separate them. The effecting of such separation is the fundamental essence of the soap-maker's business, who seduces the fickle fatty acid to desert the feeble glycerine by presenting to it a more powerfully attractive base, thus forming another salt, which is the soap. Here we have another paradox—a salt which is not saline, like the acids that are not sour.

Most of the metallic oxides are basic, and strong enough to displace the glycerine, and thus produce a soap. I may here add a generalisation of my own which I believe to be sound in spite of its origin, viz., that all basic metallic oxides which are soluble in water produce soaps that are

similarly soluble, while those which are insoluble produce insoluble soaps; slightly soluble bases, such as lime, produce soaps still less soluble than themselves. The practical bearing of this will appear presently.

A good illustration of these general laws is afforded by the old method of manufacturing glycerine for pharmaceutical uses. Litharge, the primary and decidedly basic oxide of lead, was added to olive oil and the mixture heated; the litharge united with the fatty acid, forming a dense insoluble lead soap, the glycerine separating as a liquid that floats over the soap, and therefore was easily separated. The lead soap was turned to useful account as the *emplastrum plumbi*, or diachylon, familiar to all as the yellowish adhesive substance that is spread upon linen or calico to form common "sticking plaster."

Substituting a soluble basic oxide such as soda, the oxide of the metal sodium, or potash, the oxide of potassium, we have the business of the soap-boiler thus displayed in simple, elementary, and I may add, very desirable form, the business of too many of our modern soap-makers being by no means simple and elementary, too much of their results being a complex saponaceous substance rather than a soap.

In thus using a soluble base, and that base dissolved in water, the fate of the glycerine is not so simple as in making the lead soap. Glycerine being a liquid diffusible through water, it remains in the "mother liquor" (the juice that remains after separating the soap), mixed with a little alkali and much salt. The saline matter is gradually removed by concentrating the liquid by evaporation, and then the concentrated solution is distilled by the aid of superheated steam, which carries over the glycerine, leaving a mass behind that is more or less alkaline.

The salt above referred to finds its way into the mother liquor by the means adopted for separating the soap from it. This is simply the addition of common salt to the crude solution of soap. As soap is not soluble in brine, such addition causes the soap to solidify and rise to the top as a sort of scum that is easily removable.

There are many kinds of soap. If potash is used as the base, the soap is soft. This I suspect is an analogue to other salts of potash which are very liable to deliquescence. Soft soap is usually made softer by allowing the glycerine and an excess of alkali to remain. The latter renders it stronger for coarse cleansing purposes, but by no means agreeable to tender skins. This is exaggerated by the coarse materials, such as fish oils, &c., of which it is made.

The soda soaps are hard, their hardness varying with their fatty constituent and the mode of manufacture. White or curd soap is one of the hardest, and when pure is made from tallow, but is too frequently "improved" by the addition of pipeclay or even chalk. Such impurities are easily detected by dissolving the soap in hot *distilled* water in a glass vessel, where the insoluble improvements will settle down as a visible and measurable deposit.

Yellow soap contains varying proportions of rosin or colophony which combines with alkalis when heated. The cleansing powers of the compound thus produced are not equal to that of true fat soap, but its existence in small proportions is not altogether objectionable, as the resinous constituent is a disinfectant.

"Old Brown Windsor Soap" was once very popular. Its fatty constituents then were 2 parts of good tallow and 1 part of olive oil, to which were added oils of bergamot, cumin, thyme, and caraway for perfumes, and burnt sugar for colouring. But these are now traditional constituents, and the fame of this soap has departed; its colour appears to have been fatal, as it admits the use of dirty unrefined fats, the offensive odour of which is masked by the perfumes. The mottled soap usually sold in bars owes its mottling to such impurities as sulphide and oxides of iron. It is made of refuse fats of very miscellaneous character.

Castile soap was formerly so pure that it was selected for medicinal preparations. It was then made from good olive oil, and the soda obtained by burning sea-weed. It is now much cheaper, and largely made from refuse olive oil, to which is added cotton-seed, poppy-seed, and other oils. The mottling is due to grey protoxide of iron mixed with more or less of the darker sulphide. An instructive change may be watched in this soap. When the bar is newly cut across, its interior displays a dark grey mottling. If this section is now exposed to the air a further supply of oxygen is taken up by the iron and the colour changes to the well-known tint of iron rust, which is a higher oxide combined with water. The same change occurs in our London clay, which at a little depth below the surface is of dark bluish grey colour and changes to reddish brown on exposure to the air.

The best transparent soaps are made by dissolving a good soap in about an equal weight of hot alcohol, allowing the solution to cool and the impurities to settle down. This solution gradually solidifies. The addition of glycerine renders it a glycerine soap. It was formerly made in this manner from Castile soap, and sold as "wash-balls." I have thus made it for my own use, and found that, after the settling down of the iron oxide, a rich brown colour still remained. Although it is still possible to obtain such soap, there are now in the market many kinds of transparent soap largely adulterated with sugar and other cheap make-weights; some of it, if kept for a while in a dry place, becomes ornamented with an efflorescence of crystals that may be admired from an æsthetical point of view, but are abominations to the skin.

I have already referred to the tasteless silicic acid, and am sorry to be obliged to add that it is largely used as an adulterant to soap. It combines with soda and potash, thereby forming "water-glass" with excess of alkali. This water-glass readily mixes with true soap, and unfortunately improves its appearance, smoothness, and strength, but is most vexatious to the skin, whether used as a toilet soap or by the laundress, whose hands are continuously immersed in its solution. I speak now of samples that I have examined, without denying the possibility of adding silica in harmless proportions by keeping down excess of alkali.

Toilet soaps are chiefly distinguished from bar soaps by their shape and price. Ordinary soap, more or less perfumed, and pressed into fancy moulds, becomes converted into toilet soap at a cost of 10 to 50 per cent. upon the price of the bar material, and is then sold at an advance of 100 to 500 per cent., to people who believe that price is a measure of quality.

Soap always contains more or less of water, in some cases far more than is desirable, so much as to become an adulterant. A few years ago two men brought to my door some "salvage soap" at 2*d.* per lb., said to come from a wrecked ship. I handled it, and told the gentlemen that 2*d.* per lb. was a high price for water. A neighbour bought a few bars and stored them in a dry place. A few weeks after the bars had shrunk to mere ropes about one-eighth of their original bulk. Such shrinkage measured by loss of weight affords a simple measure of such adulteration.

The scum that rises on hard water in which ordinary soap has been used is a lime soap, due to the combination of the lime in the water with some of the fatty acid of the soap. Hard water thus becomes an expensive washing medium, as its lime must be thus saturated at the cost of the soap before the remaining soap can properly do its duty.

MEAL AND TABBY MOTHS.

By E. A. Butler.

EVERYBODY is familiar with the tiny creatures which, much to the annoyance of the tidy and thrifty housewife, flit about our houses, settle on our walls and windows, or invade our most private apartments and commit suicide in our wash-basins, and which are indiscriminately, and more or less justly, called clothes moths—a name often abbreviated and used collectively in the form, "the moth." To these interesting little insects, which, in repose, take a cylindrical or parallel-sided form, we had the pleasure of calling the attention of the readers of KNOWLEDGE on a former occasion. But, though the chief representatives of the great order Lepidoptera the townsman is likely to catch a glimpse of, they are not the only members of that attractive group that more or less completely domicile themselves with mankind.

We may occasionally see perched here and there about our houses, especially in the kitchen regions, little *triangular* moths, of a considerably more robust build than the insignificant little marauders referred to above, but still of no very great size. They are members of an exceedingly curious group of moths called the "Pyrales," a group not very largely represented in the British Isles; several of the species, however, are amongst our very commonest insects. All the members of this section have the fore wings rather narrow, but the hind pair broad and ample; the latter have to be folded lengthwise when closed, in order to allow the narrower fore pair to cover them, and so, by the close apposition of their edges, to give the insect, when it takes up its position of rest, the shape of an isosceles triangle. The body is narrow, rather long, and tapering almost to a point—a characteristic which at once distinguishes this group from the common Noctuæ, or full-bodied moths; the legs, too, are long and slender, and the antennæ are usually delicate and threadlike. In many cases the wings are very shiny, and even iridescent, and one family, in consequence of their delicate pearly lustre, are popularly called the "Pearls." Some of the Pyrales are exceedingly handsome in coloration, being resplendent with crimson and golden yellow, or richly adorned with the deepest velvety black, relieved by spots and streaks of silvery white; but, as usual, the majority are more soberly clad in drabs, greys, and browns.

To the ordinary observer, no doubt the most familiar species is the "Meal moth" (*Pyralis farinalis*) (fig. 1). This is a very pretty little insect measuring about an inch in expanse of wings, though specimens are frequently met with considerably smaller. The actual size is largely determined by the amount and character of the food that was available to the insect in its immature stages. If food is scarce or of an inferior quality, the moth becomes small and stunted; but if rich and plentiful, a superior size and more sleek appearance is sure to attest the fact. The dark patches at the base and apex of the fore wings are reddish grey, the colour being richest towards the upper edge of the wing. Bounding the basal patch on its outer side and the marginal one on its inner edge are two exquisitely delicate wavy white lines, and then all the space between these is of a rich yellowish grey, slightly clouded below and darker. The hind wings are grey, and are crossed by two wavy white lines, which appear like feebler continuations of those on the fore wings, and a row of distinct black dots at the inner edge of the marginal fringe gives a pretty chequered appearance, and relieves the monotony of the ground colour.

1. MEAL MOTH.

The caterpillar is a pale, uninteresting looking creature, with reddish-brown head, and a hard, pale reddish-brown plate just behind the head, and another at the other end of the body. In its gastronomic relations it is specially attached to the cereals, the produce of which it will eat in any condition, whether as corn, flour, meal, bran, or even straw. It has also been known to feed on clover. The moth appears during the summer months, and its presence in houses is most to be expected when the flour-box is kept constantly well-stored, or better, when a sack of flour is kept. Hence such institutions as workhouses, hospitals, asylums, &c., where large stores of farinaceous substances are necessarily kept, may be expected to produce it more abundantly than ordinary houses. For this reason also it occurs in flour-mills, barns, granaries, and stables, and in bakers' shops, and, indeed, it may be expected to turn up wherever its food is housed in quantity.

For example, a certain French entomologist found his house infested with the insect, and for a long time could not discover whence they came. At last he traced them to a large box of bran on his neighbour's premises. Here they had bred in hundreds, and then had entered his house by the open window. It has even been met with in a coal mine in Yorkshire more than a quarter of a mile underground. An entomologist, on visiting the colliery, saw some of the moths flying about in the workings, and quantities of the remains of others in the cobwebs with which the place abounded, so that the species was evidently well established there. It had, no doubt, been introduced with the oats for the horses employed below ground.

The caterpillar of this moth is not nearly so easy to find as the perfect insect; the latter delights to perch on walls, and may sometimes be seen in scores, boldly sitting in perfectly exposed situations on the walls of a flour-mill. But the caterpillar loves retirement, and this alone, apart from its unattractive appearance, will account for the fact that its habits remained very imperfectly known to entomologists long after the moth had become a most familiar insect. The caterpillar constructs long tubes composed of particles of dust and flour or meal, or whatever its food happens to be, spun toughly together with silk of its own manufacture, and, protected by these, it easily pursues its depredations without being discovered. But though it may thus escape the vigilance of human eyes, it cannot manage to elude the penetration of the maternal instinct of the ichneumon flies, which are ever on the watch for the well-nourished bodies of caterpillars in which to deposit their own eggs; and so even this well-concealed larva has sometimes to succumb to the attacks of *Exochus mansuetor*, an ichneumon fly whose maggotlike offspring devour its very vitals. The life of most caterpillars extends only over a few months, or even weeks, but the caterpillar of the meal moth is blessed with greater longevity, for, being hatched in the autumn, it survives the snows of two winters, and does not become a perfect insect till the summer of the second year. It spins a tough, white, silken cocoon, which fits closely upon the glossy chrysalis within.

Two other members of this genus are well-known British insects, though they are not to be regarded as house-frequenters. One of them, *P. glaucinalis*, usually about the same size as the meal moth, or a trifle larger, has glossy dark reddish-grey fore wings, crossed by two delicate yellow lines; the other, *P. costalis*, is much smaller, and is one of the most exquisitely-coloured insects we have. It is

XUM

popularly known as the "Gold Fringe," because the marginal fringes of all the wings are bright golden yellow, a most unusual style of ornamentation. The ground colour of the wings is a delicate pink, which, especially in the fore pair, is more or less suffused with glossy grey; on the front margin of the same pair there are also two large yellow blotches, which towards the middle of the wing suddenly thin away into tiny golden threads, and thus finish their course to the opposite edge. Anything more charming than this little gem, when freshly disclosed from the pupa, can scarcely be imagined, and words seem too tame to do justice to its glories. It is not so common as the meal moth, and seems chiefly to frequent gardens.

With the meal moth one always mentally associates another common insect called the "Tabby" or "Grease moth" (fig. 2). Though not belonging to the genus *Pyralis*, it is nearly related thereto, and exhibits kindred habits in its earlier stages, and is, moreover, a house frequenter. It is scientifically known as *Aglossa pinguinalis*. It is considerably larger than its cousin of the meal-tub, often reaching an expanse of an inch and a half; but it is far less attractive in appearance, being merely dark greyish-brown, with the fore wings crossed by zigzag blackish lines, suggestive of the markings on the sides of a tabby cat, whence one of its popular names.

2. Grease Moth.

The caterpillar begins life as a minute, pale, flesh-coloured grub, but as it grows its colour deepens, until at last, when full fed, it becomes quite black. Like that of *P. farinalis*, it constructs silken tubes in which it obstinately remains concealed till full-fed, living in almost total darkness. It is to be sought for in barns, stables, and outhouses, amongst the accumulations of vegetable rubbish that abound in the corners of such places. The rubbish serves it both as food and as materials for strengthening the walls of its tubes on the outside; on the inside they are smoothly lined with dark grey-brown silk. The pertinacity with which the larvæ remain in the seclusion of their galleries renders any observations on their habits and life-history a difficult matter, and often information can only be gained at the cost of the lives of some of the specimens, as they are pretty sure to be more or less injured in the endeavour to eject them from their place of shelter.

The popular name "Grease moth," and the scientific name *pinguinalis* (greasy), both refer to habits with which this species has been credited for the last 150 years, though considerable doubt has during the last few years been thrown upon them. It has usually been stated that the caterpillar feeds on fat, butter, lard, and other greasy matters; but as the creature is of such retiring habits, it was not easy to make reliable observations on the subject in order to test the accuracy of the statement. It seems, however, *à priori* rather unlikely that the food should be of this character, as greasy substances such as those enumerated have an injurious effect on insect life in a way the following considerations will indicate. Insects breathe through their sides, air being admitted through a series of minute openings, the spiracles, which lead into the breathing tubes which run throughout the body; now, if in any way these spiracles should become clogged, the insect would necessarily be suffocated. But if the caterpillar were to be perpetually eating soft oleaginous substances like butter and lard, and thus to be always living in the midst of grease, it is difficult to understand how it could avoid getting its body in a very oily condition, and nothing would tend more easily and effectually to clog up the spiracles than such a condition. Accordingly, it has been stated that this insect is gifted with a special power of retracting its spiracles and protecting them by folds of its skin; but the evidence for this is not very satisfactory, and the recent and very careful investigations of the late Mr. W. Buckler, who devoted much time to the study of the subject, do not tend to substantiate the statement at all, but seem rather to indicate that the insect has no more power than any other to protect itself from the injurious effects of an oily condition of its skin. Mr. Buckler tried on several occasions to induce a caterpillar to eat butter and lard, by putting it with these substances under a large glass, but he says, "In every case it seemed carefully to shun both, and though I contrived once that it should at least walk over some lard, it did so nimbly enough, but could not be induced to walk over it a second time, invariably swerving aside." Nor did greasy cloth present any greater attractions, though the insects fed readily enough on a collection of rubbish which contained husks of wheat and oats, fragments of straw and thatch, and of pods of beans, small seeds of various kinds, short bits of grass and other dried stems, woolly dust, empty pupa skins of small moths, and a quantity of undeterminable chaffy and earthy matter.

A good idea of the mode of life of these insects may be obtained from a description given by Mr. Buckler of a colony he discovered in a stable. They were found in a dark corner between the oat-bin and the wall. There was only a very narrow space between the two, but quantities of grain and chaff and particles of straw frequently fell into it when the oat-bin was opened. On the cool and damp floor beneath the caterpillars had constructed their tubular galleries, which were perfectly flexible, and readily adapted themselves to any irregularities of the surface. The tubes were covered with fragments of straw and husks, and therefore, on being removed, they looked simply like strings of rubbish held together in some mysterious and invisible manner, so completely were the silken tunnels concealed. The caterpillars made no attempt to resist the forcible deportation of their residences, and took good care to remain indoors until summarily ejected.

In such situations as these the caterpillars live and thrive from September till the following April, spending the coldest parts of the winter, however, in a more or less torpid condition. When the time for pupation arrives, at the beginning of May, they desert their galleries, and wander about seeking a suitable situation for forming the cocoon. Having found one to its taste, the grub proceeds to surround itself loosely with a tough silken cover, taking care to intermix with the silk particles of rubbish such as will render its appearance sufficiently similar to that of its surroundings, and thus serve as an effectual disguise. To the inside of this cocoon the pupa clings by some recurved hooks, with which, like the meal moth, the tip of its tail is furnished. The moths appear in July and August.

Réaumur has described this insect as making a tube and devouring the leather coverings of books; a species of depredation which was much more practicable in the days when books were always bound in leather than it would be in these modern days of cloth and paper bindings. He also states that he found it eating the dry bodies of dead insects.

There is a smaller species of *Aglossa*, similar in appearance to *A. pinguinalis*, but much less common. It is called the "Small Tabby" (*A. cuprealis*). It is paler than the commoner species, especially in the hind wings. Its habits are very similar to those of the insect already described, and it occurs in similar situations, where, like its congener, it feeds on vegetable refuse. This must, however, not be too dry, or the larvæ become smaller and appear half starved:

too much moisture, on the other hand, would generate mildew, which would be equally harmful to health. The duration of the life of this insect is uncertain; sometimes it completes all its changes in a twelvemonth, but more frequently it prolongs them over a period of two years, the excess of time in the latter instance being caused by a longer larval existence, the egg and pupa stages lasting for the same time in both cases.

VARIABLE STARS.

By W. H. S. MONCK, M.A., F.R.A.S.

THE discovery of variable stars is of comparatively recent origin. New stars had indeed more than once suddenly appeared in the sky and again disappeared at various times. It is said that the earliest known catalogue—that of Hipparchus—was suggested by such an appearance about the year B.C. 134, and several others are recorded, though it is often doubtful whether they were not comets or meteors. Two grand new stars, however, appeared in the years 1572 and 1604, and attracted general attention. Science was then sufficiently advanced to suggest that these stars were not newly-created bodies, but stars constantly existing in the sky which had suddenly received a great accession of light. I doubt, however, if the discovery of a true variable star can be referred further back than the year 1639, the same year in which a transit of Venus was first observed by Horrox. In that year Holwarda observed the reappearance of a star whose disappearance he had noted during the preceding twelve months. This was the star now known as *o* Ceti or Mira. It had been observed previously, but Holwarda appears to have been the first who established its existence as a permanent star subject to periodical variations in its light—these variations being so considerable that the star is wholly lost to sight during a considerable part of its career. Thirty years later a second variable was observed by Montanari. He found that another well-known star, Algol or β Persei, was liable to periodical fluctuations in its light, though it remained visible to the naked eye throughout the entire change. These two stars are probably the most remarkable variables visible in our latitudes, being excelled only by η Argus, whose southern situation prevented his variability being noticed until many years later.

Before noticing subsequent discoveries, I may remark that while Algol and Mira agree in the marked variation of their light, the contrast between them in other respects is so great as to render it almost certain that the causes of variation in the two instances are not the same. The period of Algol is less than three days; that of Mira is over 330. Mira at its greatest brilliancy is nearly as bright as Algol; but while Algol at its minimum never sinks as low as the 4th magnitude, and is always plainly visible to the naked eye, Mira is for months at a time out of the range of ordinary telescopes, and can be little, if anything, above the 10th magnitude at its minimum. According to the scale now usually adopted in measuring the light of stars, a depression of one magnitude means a reduction of the light in the proportion of about 5 to 2. This is about the total reduction in the case of Algol, while in that of Mira the reduction can scarcely be less than six magnitudes, or about 250 to 1. The light of Algol is constant for about sixty hours out of every seventy during which time it has its maximum value; the light of Mira appears to be constantly changing. Algol appears to be equally bright at all its maxima and all its minima, and its period never varies more than a few seconds. But the light of Mira is much fainter at some of its maxima than at others, and the period is not so regular as that of Algol. The difference between these stars is brought out more clearly by the spectroscope. No star with a spectrum similar to that of Algol is known to vary in a manner similar to Mira, and no star with a spectrum like that of Mira is known to vary in a manner similar to Algol.

Great attention has been paid to the subject of variable stars of late years, and more than one excellent catalogue has recently appeared. The number now known may be set down at 250. Many of these, however, are not visible to the naked eye. As already intimated, these stars belong to very different types, and though it may not be possible at present to give a complete classification or to assign causes for every observed variation, certain classes can at all events be clearly distinguished. Of these, the most remarkable may be called the Algol type and the Mira type. The latter are much more numerous; in fact, they probably form a majority of the entire number of variable stars hitherto discovered.

A variable star of the Algol type exhibits no striking peculiarity in its colour or its spectrum. Its period (at least so far as our present knowledge goes) is always short. Its light remains steady at the maximum during considerably more than half the period between two minima, when it first declines and then again increases, the periods of increase and decrease being about equal. The minima return with such regularity that they can be predicted within a few seconds.* In short, all the facts seem explicable by supposing that a large dark satellite makes periodical transits across the face of the principal star. For some stars of this type Professor Pickering prefers a cloud of meteors to a single satellite; but unless Saturn's rings are composed of meteor-clouds, we know of no meteor-cloud which possesses nearly the required density. It was noticed some time ago that as the satellite must approach and recede from the earth (or rather from the solar system) in the course of its journey, the principal star must likewise approach us and recede from us under the attraction of the satellite. Attempts are accordingly being made at Greenwich to ascertain whether this is the case with Algol, by measuring spectroscopically the velocity in the line of sight before and after the minimum. The task is one full of difficulties; but there is no reason to despair of ultimately receiving a definite answer. So far the Greenwich results are in favour of the theory which ascribes the variation in question to a satellite. It would be difficult to frame any other theory capable of explaining the facts. Rotation of a body having different intensities of illumination on opposite sides will hardly account for the light remaining constant for sixty hours, and then falling in four or five hours to two-fifths of its former value. The stars of this type are not numerous. One of them completes its period in less than twenty-one hours. In some others the period exceeds that of Algol.

Stars of the Mira type are much more abundant. The star is almost always a red star, and presents a class of spectrum, which, though common in red stars, is not universal among them, the dark lines of the solar spectrum being replaced by bands. Many red stars which do not vary present a different kind of spectrum. Of these Aldebaran may be taken as an example. In addition to the characteristics already mentioned in the case of Mira, the periods of increase and decrease are usually different, the increase of light being as a rule more rapid than the

* Since this was written Mr. Chandler has found a change of two minutes in the period of his variable star in Cygnus, which was only discovered in 1886. The period of this star is about 1½ days.

XUM

decrease. The period is generally not very different from that of Mira, viz., 300 to 400 days. The light always becomes redder at the minimum, and at this period the star often looks as if enveloped in a haze or fog. It is plain that we have here no satellite to deal with, and rotation on an axis does not seem a probable explanation, for successive periods do not appear to be exactly equal, nor is the star equally bright at different maxima. Some of the phenomena suggest the presence of a nebula which allows red light to pass more freely than light from the violet end of the spectrum. But I am inclined to think that the nearest analogy to the Mira type of variable star is afforded by the phenomena of sun-spots. Though the sun-spot period is more than ten times as long as the average period of the stars in question, and the diminution of light is very much less, there are other features which agree in rather a striking manner. The interval between two sun-spot maxima does not appear to be exactly the same. The spots are more numerous at one maximum than at another. The periods of increase and decrease of spots are usually unequal, the latter (corresponding to the increase of light) being most rapid. The spectrum of a sun-spot shows a thickening of the solar lines, thus approximating to the spectrum of Mira. The sun-spots thus appear to me to afford a better explanation of variable stars of this class than any other facts within our observation, though the phenomena of sun-spots must be enormously exaggerated to produce such results as we witness in the case of Mira. It is not impossible that a great exaggeration of sun-spots in past ages may have produced what is known to geologists as the glacial period. Were we dependent for our light and heat on such a body as Mira, glacial periods would probably be of very frequent occurrence. Independently of the contrast between the light (and probably the heat) at maximum and minimum, Mira gives at least three times as much light at some maxima as it gives at others.

Besides the Algol type and the Mira type, however, there is another remarkable class of variables, viz., New Stars. Among the brightest of these hitherto recorded are those of 1572 and 1604, the light of both of which when at the maximum exceeded that of any fixed star in the sky. Others belonging to the same class, however, have scarcely, if at all, passed the limit of naked eye vision. Thus the new star in Andromeda, which appeared in 1885, was probably never seen without optical aid. It is not always easy to distinguish stars of this class from those of the Mira type, which at times entirely disappear from the firmament; and it seems almost certain that Mr. Gore's so-called New Star in Orion is really a star of the Mira type, with a period of about a year. The true New Stars, however, as far as I can judge, exhibit no periodicity, and are always found in, or close to, a nebula. The phenomena are strongly suggestive of a star rushing through a gaseous nebula, and intensely heated on the surface by the resistance of that medium; but the heating appears to be merely superficial, and fades away rapidly when the star once gets clear of the nebula. Such stars, though their distances and magnitudes are vastly greater, may be likened to meteors whose intense light is caused by rushing through our own atmosphere. Owing to the irregular shapes of nebulæ, and the possibility of the star moving in a closed curve, it seems quite possible for a star, after clearing such a nebula, to enter it again; but this can hardly be said to have been hitherto established in the case of any star. The great stars of 1572 and 1604 have not reappeared, and their smaller compeers since observed have never recovered their former brightness. If there is any exception to this rule it is in the case of the famous variable η Argus, which in the course of the last forty-five years has descended from being the rival of Sirius to become a telescopic star invisible to the keenest eye. But this star is known to have varied previous to its last maximum, and some astronomers have even described it as a periodical variable. I cannot trace any periodicity in its variations, and though it might be rash to predict that it will never re-enter the nebula and recover a portion of its lost brilliancy, I do not think it is likely to be seen again as a star of the first magnitude. It is most probably a Nova or new star, which has permanently faded away like those of 1572 and 1604. We have thus a third class of variable stars. The characteristic features of this class are connection with a nebula, rapid increase of light (so rapid that the star is sometimes observed for the first time after the increase has taken place), and the absence of periodicity. I do not in these remarks intend to reject the hypotheses that nebulæ may consist of clouds of meteors and that the surface-heating of the stars in question may arise from collision with these meteor-clouds. I merely desire to assign passage through a nebula as the probable cause of variation, though I think it most likely that the nebulæ in question are gaseous.

But while our three most remarkable variables, Algol, Mira, and η Argus (which last star is evidently connected with the Coal-sack nebula) thus belong to three distinct types with different causes of variableness, there are several variable stars which cannot, I think, be reduced to any of these three classes. Such a star, for instance, is the brilliant star Betelgeuse in Orion. That Betelgeuse varies is, I think, undoubted; in fact, we had rather a remarkable minimum in the year 1887. The spectrum resembles that of Mira, and the star is of a reddish hue, but no period has been assigned, and with so brilliant a star I think, if a period existed, it would have been discovered. There are other stars bearing a slighter resemblance to Mira which come under the same head; and until some better mode of classification is discovered, I think such stars should be classed together as variable stars not reducible to any of the three definite classes already referred to. Though provisionally classed together, however, they will probably be distinguished from each other hereafter.

I may here glance at a possible cause of variation in certain stars, viz. the intervention of a nebula so situated that, when the earth is at one part of its orbit, the star is seen clear of the nebula, while at another part of the orbit it is seen through the nebula. The reason for this conjecture is the near approach of the period of several variable stars to one year. Mr. Gore's new star in Orion belongs to this class, and it is possible that the reason why it was not seen previously to the year 1885 was that it just got clear of the nebula in that year. A nebula placed anywhere between the earth and the star might produce this kind of variability if the three were nearly in a right line. A star of this kind, indeed, would not be permanently variable. It would ultimately either get completely clear of the nebula or become entirely hidden behind it. A similar remark applies to stars of the Algol type if these changes are due to a satellite. The motion of the solar system through space will necessarily place the plane of the orbit of the satellite in a different position as regards us in the lapse of time, and the transit, after first occupying less time and cutting off less light, will ultimately cease altogether. But variable stars have not been observed long enough to apply these tests. As regards variables of the Mira type, their changes may continue as at present for an indefinite period, at least so far as our power of prediction reaches.

Many variable stars can be observed with the naked eye. Others can be detected with no further aid than a field-glass or hand telescope. The subject is therefore within reach of almost every one. Catalogues have lately been published by

Mr. Gore through the Royal Irish Academy and by Mr. Chandler in the *Astronomical Journal*, in which the reader who desires to pursue the subject further will find almost all the information that he requires.

A PHOTO-GEOLOGICAL TRIP TO THE SOUTH STACKS.

By W. JEROME HARRISON, F.G.S.

FOR many years past, North Wales has been to me in my summer holidays a happy hunting-ground, over which I have strayed, hammer in hand and camera on my back, rejoicing in the beauty of its scenery and pondering over the marvellous complexity of its rock structure.

Now that the gelatine dry-plate process has made photography so easy, every geologist ought to carry a camera, for in no other way can he bring back such accurate and rapidly-produced facsimiles of the quarries he visits, the railway cuttings or coasts he examines, or the scenery whose origin it is his office to explain.

The north coast of Wales, from Prestatyn to Holyhead, is, indeed, a paradise for the student of nature; and, when the tourist takes his ticket per the London and North-Western Railway for its terminus at Holyhead, the journey ought to be broken at several points, certainly at Conway and at Bangor, to make a detailed investigation of its beauties.

Crossing the Menai Straits through Stephenson's Tube, we speculate on the truth of Ramsay's theory—that the island of Anglesey was separated from the mainland by the action of a great glacier which descended from the mountains of the Lake District, ploughed its way over the bed of what is now the Irish Sea, overcame and turned aside the opposing glacier from Snowdonia, and finally grooved out a narrow channel in the comparatively soft and broken rocks which then connected Anglesey with the rest of Wales. Proofs in favour of this theory are the boulders of Lake District and of Scottish rocks, which are now spread along the northern margin of Wales. The visitor to Prestatyn, or Penmaenmawr, or Llanfairfechan, can find plenty of blocks of northern granites and volcanic rocks (the latter usually well smoothed and striated as if by ice). Then the general smoothing and grooving of the Welsh rocks along either side of the Menai Straits, the main grooves and striations running parallel to the line of the Straits, still remain to attest the passage of this old glacier. The severance of the island from the mainland must, then, have been the work of ice during the last Glacial period, which occurred possibly a quarter of a million years ago, when 'a shallow valley was scooped out in comparatively soft ro cks by the grinding power of the vast glacier coming from the north-east; and when in course of time the climate ameliorated and the glacier disappeared, the sea flowed in where parts of the glacier had been, and Anglesey first became an island." (Ramsay.)

Getting out at Holyhead Station, we pause on the platform to examine and arrange our "traps." As this is to be a "photo-geological" excursion, we are provided with apparatus for both the examination and the depicturing of the rocks. The photographic set includes a whole-plate camera, Eastman roll-holder containing sufficient sensitive paper to make twenty-four pictures, and a tripod stand, together with various minor articles—total weight 14 lbs. For geology proper we have a square-headed, steel-faced 2½-lb. hammer with long handle; the Ordnance Survey Map of the district; a leather game-bag to hold specimens; a compass, &c.—total weight 5 lbs. But as we fill the bag *en route* with rock specimens, their weight (about 10 lbs.) must also be taken into consideration.

But our party consists of two, and we make light of the weight, for it is a fine day, such as this summer yielded so rarely. We have prepared ourselves for a study of the district to be visited by a renewed perusal of Professor Ramsay's grand book,* and the able papers by Dr. Callaway † and by Professor Blake.‡

The town of Holyhead is a place which people usually visit in order to get away from as quickly as possible, but it has many points of interest. The very ancient church of St. Cybi, and the fine harbour and breakwater, attract attention. We watch a Dublin packet steam up to within a few feet of the railway platform, and we gaze at the tiny isles called the Skerries, which lie seven miles to the north of the harbour.

Making our way out of Holyhead, we take a road bearing due west, and walk for four miles through a somewhat barren country, until the sea appears in front, when we turn sharply to the right (following the telegraph wires) and soon find ourselves on the summit of a magnificent series of cliffs, against whose jagged and precipitous sides the waters lash themselves in foam 500 feet below, while myriads of birds cover every possible resting-place or circle unceasingly in the air. Standing by Lord Stanley's summer-house (built on the very verge of the cliffs) the scene is, indeed, a grand one. The Irish coast—fifty miles to the west—is distinctly visible, and several steamers are passing up St. George's Channel. But the chief attraction lies at our feet, where the lighthouse—a slender white cone surmounted by a glass lantern—stands on a little island which is connected to the mainland by a pretty suspension bridge. Several whitewashed dwellings (the love of the Welshman for whitewash is very great) cluster round the lighthouse—the homes of the keepers, and the whole is surrounded by a white wall intended to prevent the inhabitants of the islet from accidental falls into the sea. Descending a zigzag of 400 steps, we are courteously received and shown the machinery of the light, the fog-bell, &c.; but our chief interest is concentrated in the appearance of the cliffs as seen from near the sea-level. The rocks (which we examined during the descent) consist of alternating layers of grit—a hard sandy rock—and greenish micaceous schist. These are thrown into the most remarkable folds and curves, and each seam or layer has a crumpling of its own, which gives the whole a "gnarled" appearance. In the islet itself, on the south side, the rocks are seen to be bent into a perfect arch. No fossils occur in these rocks; and, indeed, if any were ever present in them we could scarcely expect to find any traces now; for these beds form part of *the basement rocks of the British Isles*, and they are so old, and have been so altered by heat and by pressure deep down in the earth, and by the earth-movements in which they have taken part, that any included traces of life would have pretty certainly been obliterated. All the strata from Holyhead to Harwich, from the west of England to the east—strata above 100,000 feet in thickness—have been deposited since these South-Stack rocks were first formed, and can be proved to lie above and to rest upon them. Three theories have been advanced with respect to their exact age. Sir A. C. Ramsay—the late Director of the Geological Survey—argues that these and all other similar strata in Anglesey

* "Geology of North Wales." Second Edition. 1881. Stanford.

† *Quarterly Journal Geological Society*, for 1881, p. 210; and for 1884, p. 567.

‡ *Ibid.*, 1888, p. 463.

are the "altered and metamorphosed representatives" of the Cambrian formation, whose slaty strata form so much of North-west Wales. But recent chemical and microscopical researches into the minute structure of rocks goes far to prove that any such extensive and radical alteration as this theory would require is impossible.

Dr. Callaway—and perhaps we may add modern geologists generally—would assign the South-Stack strata to that Archæan or "Pre-Cambrian" formation whose gneissic rocks are the oldest known upon the face of the earth. The Laurentian formation of Canada and the Hebridean gneiss of Scotland belong approximately to this early epoch in the world's history.

Professor Blake, however, would assign most of the rocks of Anglesey—under the name of the *Monian System*—to a period intermediate between the true Archæan and the Cambrian. He correlates them with the Longmynd beds in Shropshire, with the beds at Bray Head in Ireland, and with the strata of the Wrekin and of Charnwood Forest. If this view be correct, we may yet hope to find fossils in some of the Monian rocks of Anglesey (all the strata are not so much metamorphosed as the South-Stack series); for scanty traces of life have been found both in the Longmynd hills and at Bray Head.

But time passes quickly when occupied with camera and hammer at the South Stacks. If we visit the islet in the breeding season, any time between the end of February and the beginning of August, a multitude of sea birds, especially gulls, razor-bills, guillemots, and cormorants, will be found to literally cover the rocks. There are no puffins, but the peregrine falcon nests in the most inaccessible crags. The birds are strictly protected, since their piercing cries give valuable warning in foggy weather of the proximity of the land to passing ships.

Climbing up the zigzag steps—which seem to have increased in number since our descent—we return to Holyhead by a new route, passing over a hill (Caer Gybi, 709 feet) which overlooks the North Stack. On our way we explore some gigantic though now desolate quarries in quartzite rock which were excavated to yield material for the breakwater. Counting up our spoils, we reckon up twelve photographs, some choice rock-specimens, and, best of all, the renovation of body and mind which comes from contact with nature in a spot so pure and secluded as the South Stacks.

AUTOMATIC RECORDING INSTRUMENTS OF THE LICK OBSERVATORY.

THE self-recording barometer and rain-gauge figured on the opposite page were contrived by the Dr. Draper referred to in the November number, who obtained the first photograph of the lines in the solar spectrum, as well as the first photograph of a human being. It has been thought worth while to describe them in KNOWLEDGE, as they are of so simple a character that they can be easily made by amateurs—with the exception of the clockwork movements, which Dr. Draper used to make from the works of American clocks, which may be purchased in England for five or six shillings; the additional little pulley wheel fastened to the hour arbor which is necessary would be added by any working clock-maker for a few shillings more. The instruments figured on the opposite page are those in use at the Lick Observatory.

In the self-recording barometer the glass tube which shows the height of the mercury is 36 inches in length. The upper portion is made of considerably larger diameter than the stem, and must be accurately cylindrical. It is held firmly in a vertical position by brackets from the back of the case. It is inverted and filled in the usual manner with quicksilver. Its lower or open end dips into a tube or reservoir, also containing quicksilver.

This reservoir is suspended on two spiral steel springs which hang from the bracket at the top of the case, and has freedom of motion up and down. When the pressure of the atmosphere diminishes a portion of the mercury flows out of the tube into the reservoir; this, becoming heavier, stretches the steel springs, causing the ink pencil fastened to them to mark downward. If the pressure increases the reverse movement takes place. The ink-pencil makes its mark on a ruled paper register, carried at the rate of half an inch per hour from right to left by a clock.

There is a third steel spring of the same length and strength as those on the reservoir, stretched by a weight to a distance equivalent to 30 inches on the barometer scale. The object of this spring is to give the correction of temperature for those sustaining the reservoir. The movements of the mercury on the register can be magnified to any required extent by increasing the length of the spiral springs.

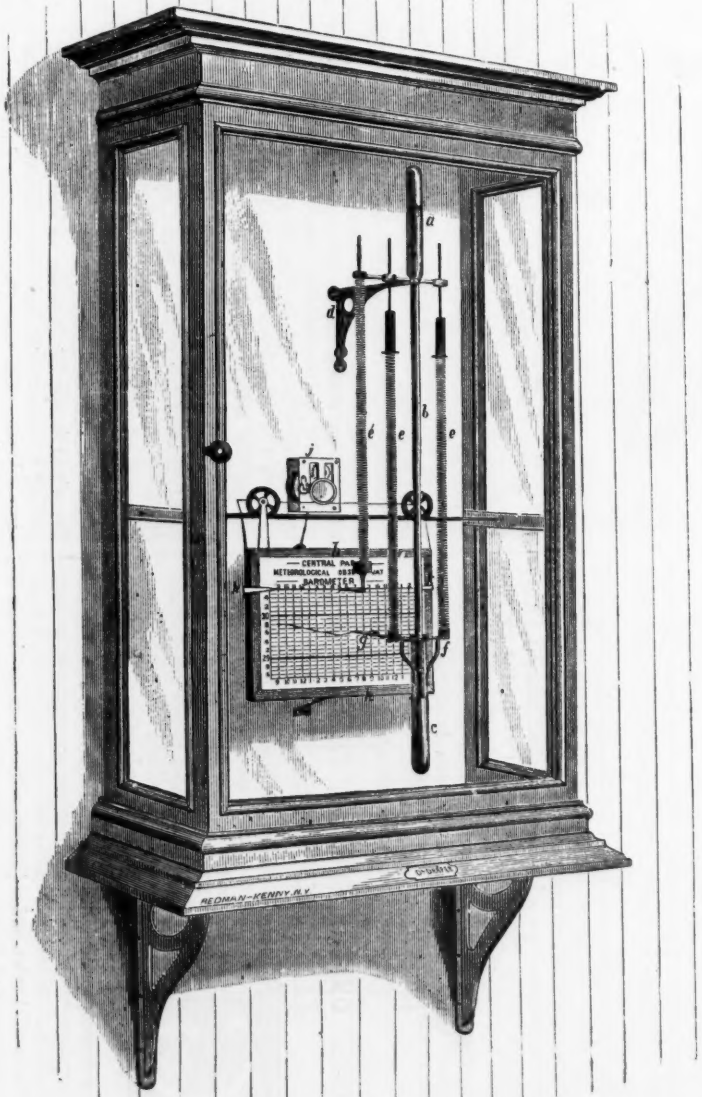
The tube marked *a b* in the cut is of glass; the upper part is of a larger diameter than the stem *a*, being, in the Lick Observatory instrument, three-fourths of an inch in internal diameter and 10 inches long, while the stem *b* is one-eighth of an inch bore and 26 inches long. The total length of the tube is therefore 36 inches. The reservoir *c* is suspended from a brass frame *d*, fastened to the back of the case. This frame also holds the upper ends of the steel springs *e e e''*. The glass reservoir *c* is of the same diameter and length as the upper part of the tube *a*; on its open end is turned a flange to hold it in a brass frame *f*, to which are fastened the lower ends of the steel springs *e e*; it also carries an ink-pencil *g* that touches the ruled paper on the board *h h*, which is drawn aside by the clock *i*. The spring *e'* is for the correction of temperature on the other springs, as will be described below.

The springs for weighing the reservoir are of steel wire, No. 22 English wire gauge, closely wound round a mandril one-half inch in diameter and 10 inches long, on which they are tempered hard, and afterward lowered to a suitable temper by being dipped in oil and ignited two or three times, the burnt oil forming a japan that prevents them from rusting.

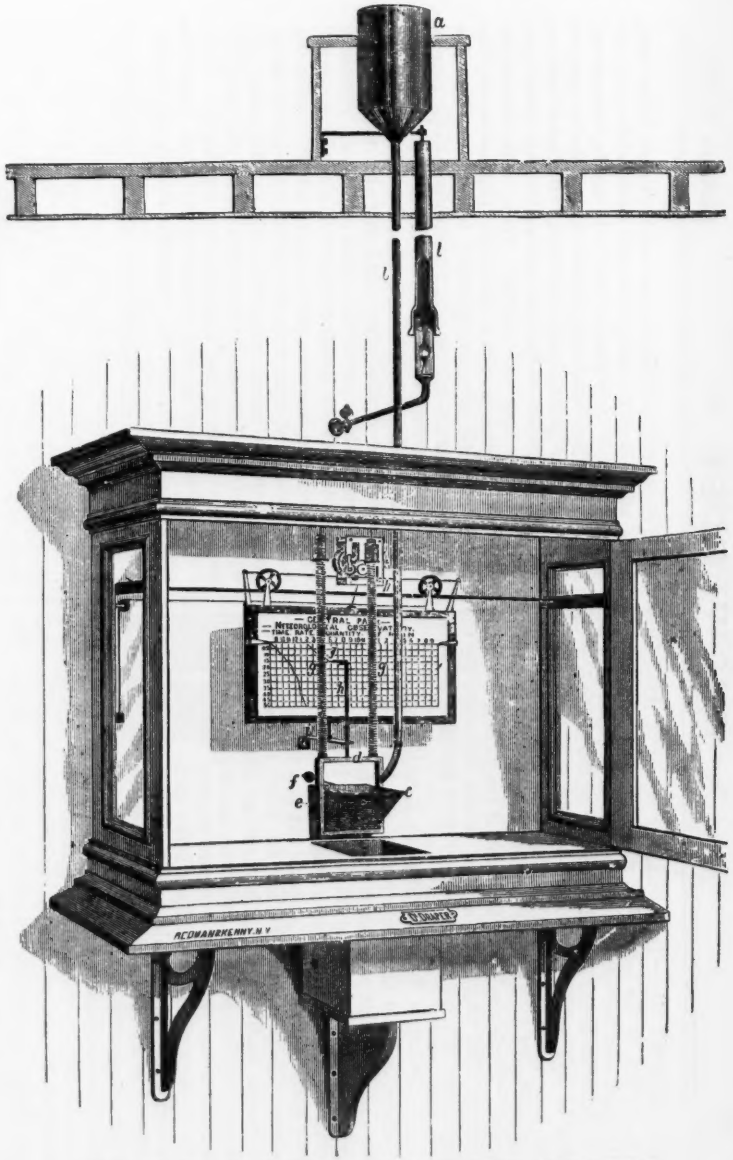
Steel springs for instruments are generally made too short and thick; that is, there is a very small range between their normal condition and limit of elasticity. These barometer springs may be stretched five times their length without taking a set, while in the instrument they are never extended more than twice their length. Heat has a slight effect on them, causing them to lengthen about $\frac{1}{16}$th of an inch for 90 degrees Fahr. To allow for this, the third spring *e'* is weighted with a lead weight and pencil; it marks its fluctuations on the upper line of the register sheet. Otherwise this instrument gives the correction for temperature (or reduction to 32 degrees) from the fact that it weighs the mercury instead of measuring its length, which is affected by heat.

Ink pencils of the barometer and other instruments are made by drawing narrow glass tubing to a fine point, which lightly touches the paper register, leaving a mark of red ink that has been diluted with about one-quarter of its volume of glycerine. The glycerine prevents the ink from drying too rapidly. The advantage of this form of pencil over lead ones is that it requires little or no pressure to produce a mark.

To receive the register of atmospheric fluctuations, a



DRAPER'S SELF-REGISTERING BAROMETER, LICK OBSERVATORY.



DRAPER'S SELF-REGISTERING RAIN GAUGE, LICK OBSERVATORY.

suitable ruled paper is fastened by means of small brass clamps, *k k*, to the board, *h h*, which is hung by rollers to the thick steel rod fastened to the sides of the case, on which the paper is carried from right to left by the clock, *i*, at the rate of half an inch per hour, by means of the pulley on the hour arbor of the clock. The wire that connects the register board to the clock is of soft steel, number 28 wire gauge. Having only one turn round the pulley, it readily slides, so that the board can be pushed sideways for the adjustment of time, or for the renewal of the sheet of paper.

DRAPER'S SELF-REGISTERING RAIN GAUGE.

About two feet above the roof of the building is placed the usual circular rain-gauge receiver, marked *a*; it is 8 inches in diameter, funnel-shaped at the bottom, and leads into a block-tin pipe *b*, three-eighths of an inch in diameter. This gauge is mounted on a square box that will be described below. The pipe descends from the gauge to the receiving or gravity bucket *c*, which is made of brass and is of a triangular prismatic shape, balanced just above and forward of its centre of gravity in a square frame *d*, by two pivots, one of them marked *e*. These allow it to tilt when the water has reached a certain height or quantity. The leaden weight *f* is an adjustable counterbalance for the regulating of the tilting of the bucket. The square frame which carries this bucket is suspended to two steel springs *g g*, placed as is shown in the drawing, that is, parallel to the register sheet, the object being that when the bucket is emptying, the pencil rises from the register and makes no return mark. The upper ends of these springs are fastened by suitable means to the top of the case. Between the springs and attached to the square frame is an upright rod *h*, going through a steadying bracket *i*, and on its upper end an ink pencil *j*, which delicately touches the sheet of paper moved sideways by the clock *k*.

The square box alluded to in the preceding paragraph not only affords a support for the gauge, but retains warm air admitted from the gas-burner in the room below by means of an iron pipe *l*, which delivers the heated air close to the bottom of the funnel, melting any snow or sleet that may collect.

The funnel of the rain gauge is 36 inches above the roof, 33 feet above the summit level and 4,333 feet above the sea.

Such self-recording instruments are adaptable to many purposes besides registering meteorological changes. They are useful in the physiological as well as in the physical laboratory, and they make excellent tide gauges and seismographs. In the Lick Observatory instruments the clockwork of the seismographic instruments is started by the shock of the earthquake.

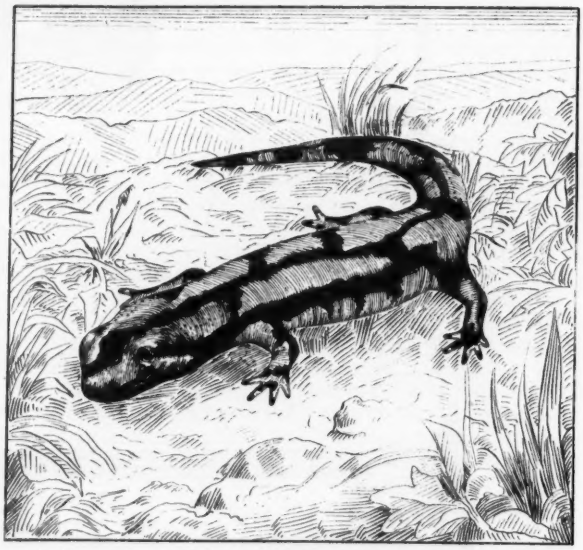
NOTES ON THE SPOTTED SALAMANDER.

BY A. J. FIELD.

CONSIDERABLE ignorance exists, even in the minds of many persons of education, as to the habits of this harmless little batrachian. The mention of salamanders recalls to the minds of most people magical and mystic ideas of the middle ages with respect to fire-eating and fire-inhabiting creatures, and I fear that these myths have caused many of the poor little brutes to be burnt by experimental philosophers who should have been far above a belief in such absurdities.

The spotted salamander (*Salamandra maculosa*) is one of the commonest of its genus. In the adult or perfect state it is terrestrial in its general habits, haunting all manner of dark, damp, and cool places, such as cavities in fallen trees, holes under logs of wood, or in old walls, where they can find a supply of their natural food, viz., insects, worms, and slugs. It is an interesting sight to watch the salamander when about to make a meal off a worm. For a few minutes he remains almost motionless, with his large black eyes turned down upon the victim. Then, with marvellous rapidity, it pounces down upon the luckless worm, the middle of which is instantly drawn into the mouth while the extremities are left twisting violently around the muzzle, vainly endeavouring to escape. All the salamander's movements are performed with such absurd solemnity that the most hardened reptile-hater could not be uninterested. This struggle between reptile and worm strongly reminds one of the old Greek legend of "Laocoon and the Serpents." The salamander, however, does not protract the conflict, but in the most grotesque manner pushes the worm piece by piece down his throat by means of his fore-legs, until the whole entirely disappears. Sometimes, when the worm is large, this operation lasts nearly twenty minutes.

The salamander is ovo-viviparous, and when born has fully developed gills. For this reason the female, when about



THE SPOTTED SALAMANDER.

to bring forth young, remains in the water until the young are all deposited.

Salamanders, in common with various other batrachians, discharge on pressure an acrid milky fluid, which has sometimes a very strong and rather disagreeable odour. They are, however, quite unable to empty the glands which contain the secretion by any voluntary act. Presumably it is to serve the otherwise unprotected reptile as a defence against the attacks of carnivorous and other animals. I have taken pains to carefully examine this secretion, and have found it analogous to that which exudes from the skin-follicles of the common toad (*Bufo vulgaris*). It is a glutinous semi-fluid, and to outward appearance is generally of a yellowish hue. It has an alkaline action, although it affects turmeric-paper but slightly. Formiates were detected by microscopical analysis in one of the constituents. The whole is soluble in water as well as in alcohol. On putting it to the mouth its action and taste resembles mercuric chloride. Zalesky, who calls this fluid samandrine, has given it the formula $C_{34}H_{60}N_2O_5$.

When taken internally it acts without a doubt as a

virulent poison. It has also been stated that if administered hypodermically the results terminate fatally; this is, however, a disputed question, nothing, in my opinion, having been proved to substantiate the assumption.

Nevertheless, that inward application in the cases of the smaller animals will prove fatal has been fully demonstrated time after time.

Some time ago I had in my possession a female sand lizard (*Lacerta agilis*) that was sadly abandoned to cannibalism. While attending to my vivarium one morning this pugnacious little saurian made a most savage attack upon one of the salamanders, biting it severely. It was no great surprise to me, for this same lizard had distinguished herself only a few days before by killing and *eating* a small smooth newt (*Lissatriton punctatus*), so I now thought I would take precaution in this case and put her in a cage by herself before a meal was made from the salamander also.

After a few minutes I happened to look in the direction of the cage, and saw that she was staggering about as though under the influence of alcohol. This at once excited my attention, and I noticed that the above symptoms were almost immediately followed by evident signs of poisoning —i.e. complete paralysis of the legs and general epileptiform convulsions. Contrary to usual experience, all control over the muscles seemed lost, the fore-legs being the only parts of which the muscular substance was unaffected. The back-legs gave constant and distinct twitchings, and the pupils of the eyes were slightly dilated. There was also viscid saliva flowing from the mouth. Half-an-hour afterwards it began to struggle violently, but paralysis was rapidly advancing, until it ceased to show any signs of reflex action; about eighty and a half minutes from my first observation, after a kind of paralytic state the lizard died.

This little incident puzzled me very much at the time, but it is now quite obvious that in biting the salamander the lizard must have had some of that batrachian's virus ejected into her mouth, which proved fatal.

The same day I made a post-mortem examination on the body of the lizard with the following results. The heart was greatly distended with blood, which was not coagulated (as is generally the case with the lower animals in poisoning), but still remained in a fluid state. The lung appeared extremely pale, and was almost bloodless. On examining the stomach it seemed evident that the poor reptile had suffered severe gastrorrhagia; the vertebral column was seriously contorted also. The uterus had been badly diseased, and was now in a state of gangrene. Probably this organ was injured previously to the poisoning, but it had no bearing on the death. No doubt anæsthesia was present, and the poor animal suffered but little pain.

After this occurrence I was quite sure of the poisonous nature of samandrine when taken internally. However, it has no danger for man, as not the slightest ill effects are produced unless it is drunk in considerable quantities. This is not at all likely to be done, for it has an extremely disagreeable acrid taste, and is quite repulsive to the sight.

The spotted salamander in colour is lamp-black, with numerous yellow spots and stripes. The eyes are very large, and there are numberless warty growths on either side of the body. The toes are not webbed, as is the case with some members of the family, such as frogs (*Ranadæ*), but are free, quite smooth, and do not possess nails. The accompanying illustration is a fairly good representation of the spotted salamander, which is extensively distributed over the whole of central and southern Europe, also in the northern parts of Africa, but is chiefly found in the mountainous districts.

In an allied species called the mountain salamander (*Salamandra atra*) the young undergo the necessary metamorphoses while in the oviduct, and are brought forth in their perfect state. Mr. Lewes tells us that if we open a gravid female "we shall find tadpoles inside her with exquisitely feathered gills, and that when placed in the water they swim about like the tadpoles of the water-newt."*

The salamander is rather tenacious of life, and has been known to live six months without food. It has been stated that common English salt (sodic chloride) is more efficacious in destroying these creatures than anything else, and when sprinkled with it the whole body emits a viscous fluid, and in a few minutes the reptile is dead.

THE HEALTH OF LONDON.

By ALEX. B. MACDOWALL, M.A.

THE graphic method of presenting numerical data is of wide utility. A simple "curve-picture" made according to it may show us, in a vivid way, three things; first, how a number of data of a given time (a year or a week, e.g.) are related to each other; secondly, how they are related to similar data in the past; and thirdly (in some cases), what is likely to happen in the future.

We here give three diagrams relating to the health of

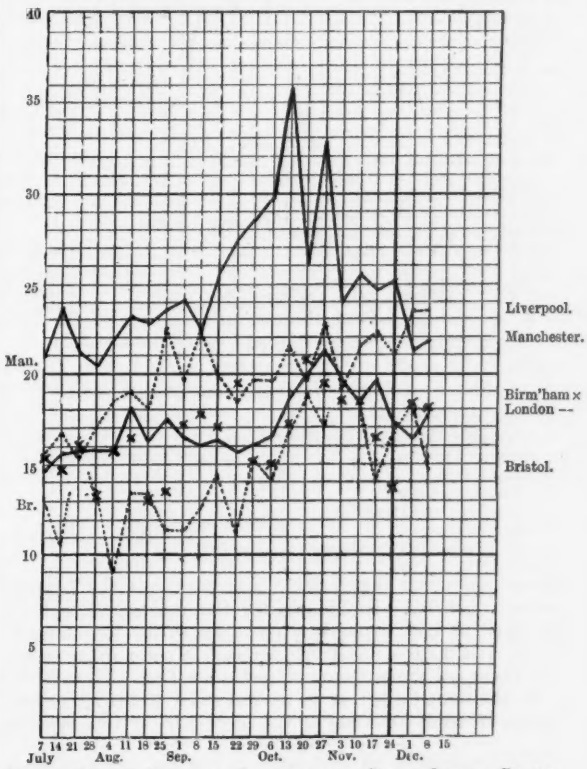


FIG. 1.—DEATH RATE OF LONDON AND SOME OTHER GREAT TOWNS.

The crosses, if joined, would give the curve for Birmingham

London, week by week, from July 7 to December 8, that is, about five months, and shall point out some of the things

* *Origin of Species*, p. 397.

they seem to teach. But the reader should study them independently.*

Our first diagram shows the death rate of London, during the five months, compared with those of some (4) other great towns.

The upper continuous curve is that for Manchester, which has one of the highest death rates among the 28 great English towns reported upon every week by the Registrar-General. The lower continuous curve is that for London. The upper dotted line curve is that for Liverpool; the lower that for Bristol (given as a town with one of the lowest death rates. This latter is a little interrupted at two points, to avoid confusion. For the same reason the Birmingham death rate is shown by crosses).

Thus we get a rough idea of the general relative course of these death-rate curves in the summer and autumn, and early winter months. The extremes are Manchester 35·7 in the week ending October 13, and Bristol 9·0 in the week ending August 4. Note the rapid rise in the Manchester

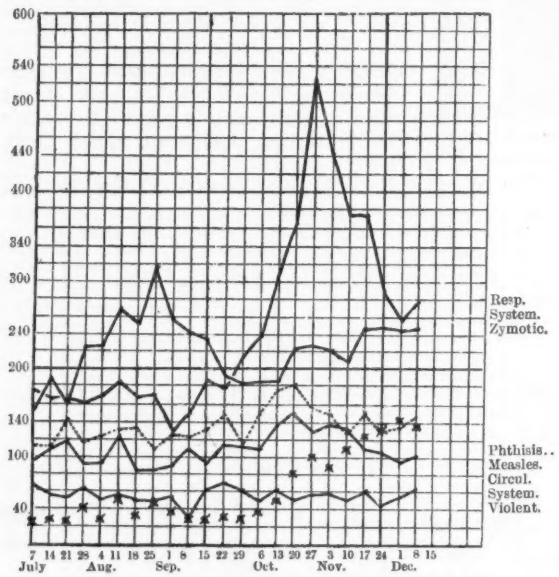


FIG. 2.—LONDON. DEATHS FROM DISEASE, &C.

Measles (December 8) . .	139	. . (83 above average).
Other Diseases (December 8):—		
Scarlet Fever	30	. . (20 below average).
Diphtheria	35	. . (14 above „).
Whooping Cough	13	. . (35 below „).
Diarrhœa and Dysentery .	19	. . (4 above „).
Enteric Fever	12	. . (11 below „).

No deaths from Small-pox (average 10).

curve from about September 8, also the rise in the London curve in October. In Manchester the rate seems to have returned, at last, to nearly what it was at the beginning of July; and there is not much increase in some other cases, but Liverpool shows the considerable rise from 15·8 to 23·6.

In the second diagram we look at some of the immediate causes of death—diseases of the respiratory system, zymotic disease, &c. The figures here are not *rates*, but absolute numbers of deaths. Note that the curves for these two just named cross each other, each having a prominent peak, the zymotic (319) in the week ending August 25, and the respiratory (522) in that ending October 27. The zymotic disease chiefly causing the former peak seems to have been diarrhœa and dysentery (not shown separately in the figure), the number of deaths from this having risen rapidly from 62 in the third week of July to 192 in the fourth week of August. We give one example of zymotic disease, showing rapid rise in the early winter, viz., measles (see the crosses). It is a curious fact that London is unlike other large towns in showing a considerable winter excess of mortality from measles besides the *summer* excess. The remaining curves show less pronounced variations. The phthisis mortality rises to a maximum, as will be seen, in October.

In this third diagram (or two diagrams in one) we have a retrospect of the weather of those five months. At the top is a curve of rainfall, there are also crosses indicating the

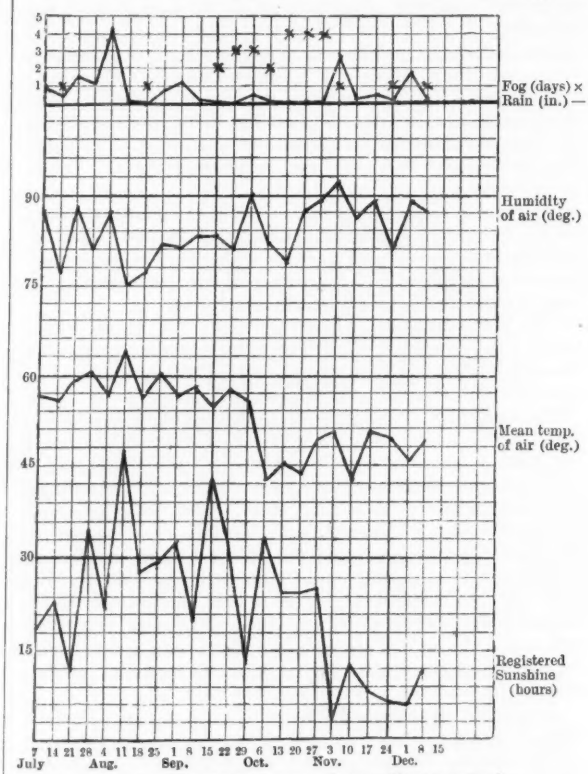


FIG. 3.—METEOROLOGICAL DATA (GREENWICH).

number of days in which fog was observed at Greenwich; and in the lower portion are three curves also, put together for convenience sake, though referring to three different things; degrees of humidity, degrees of temperature, and hours of sunshine. In the case of humidity the saturated state is supposed to be 100.

Without going minutely into the bearings of all this on health, we may point out the general correspondence between the sudden fall of the temperature curve early in October and the numerous fogs in that month, as well as at the end of September (when there were several, but fewer), and the great rise in mortality from diseases of the respiratory system, shown in fig. 2. Is it not also significant that the respiratory curve begins to drop rapidly from October 27,

* If anyone needs an explanation of how the curves are made and how they should be used, let him look for a moment at the first diagram and the lower continuous curve which has "London" opposite the end of it. To know the London death-rate for any week, e.g., that ending October 27, find the date at the bottom, go upwards till you reach the London curve. Then refer, at that level, to the figures on the left. The exact figure in this case (given approximately by the diagram) is 21·2. And so with other weeks. The curves are, in fact, a series of points joined by short lines.

just when the fog days drop from four in the week to one? The indications of the wet and dull July, and the general decline of sunshine in the autumn months, may be noted in the curves.

ON SOME STRANGE FEATS OF CALCULATING BOYS.

BY THE LATE R. A. PROCTOR.

(*Continued from page* 39.)

THERE can be no doubt that some persons possess the power of forming mental pictures so perfect as to serve all the purposes of objective realities—that is, to admit (as in the case I have supposed to be illustrated by the feats of mental calculators and chess-players) of processes which may be called mental manipulation. Most of us have experienced the existence of this faculty in dreams. For instance, we dream of reading a book and the mental conception of the book is so perfect that, as it were, we turn leaf after leaf, finding each page perfectly presented—paper, type, arrangement, &c., all pictured by a process of unconscious cerebration, precisely corresponding to the conscious action of the mind which I have assumed in my explanation of Colburn's mastery over a certain class of arithmetical problems. The same faculty is exercised by the artist who draws either from memory or by a sort of creative talent which enables him to conceive suitable forms or attitudes, and copy them as though the conceptions were realities. Dr. Richardson, in an interesting essay on hallucinations, mentions a singular illustration of this faculty in the case of Wm. Blake. This artist once "produced three hundred portraits from his own hand in one year." When asked on what this peculiar power of rapid work depended, he answered "that when a sitter came to him, he looked at him attentively for half-an-hour, sketching from time to time on the canvas; then he put away the canvas and took another sitter. When he wished to resume the first portrait, he said, 'I took the man, and put him in the chair, where I saw him as distinctly as if he had been before me in his own proper person. When I lookod at the chair, I saw the man.'"* It may be well to mention that the exercise of this faculty is fraught with danger in some cases. Blake, after a while, began to lose the power of distinguishing "between the real and imaginary sitters, so that" (the *sequitur* is not quite manifest, however) "he became actually insane, and remained in an asylum for thirty years. Then his mind was restored to him, and he resumed the use of the pencil; but the old evil threatened to return, and he once more forsook his art, soon afterwards to die."

It may perhaps appear to the reader that this case, however remarkable in itself, does not prove the possibility of conceiving with perfect distinctness other objects than were retained in the memory, and therefore is not sufficient to explain the mental feats before considered. But there are cases not less remarkably illustrating the distinctness of the mental vision, where the objects conceived were certainly not called up by an act of memory. Thus Talma the tragedian could at will picture a crowded audience as so many skeletons, each perfect in every detail corresponding to the attitude of the person thus metamorphosed. This case is the more remarkable that usually the exercise of the bodily eye interferes with that of the mind's eye. Talma was not only able to picture the theatre as full of skeletons, but they became so real in appearance, that he acted as though they were his auditors and critics: and Hyacinthe Langlois tells us that Talma's acting was rendered more intensely effective by the imagined presence of these singular spectators.

However, I am not concerned now to inquire into the nature of hallucinatory manifestations, and I mention these stories only as indicating the power which the mind possesses of calling up images of objects not merely remembered, but formed as it were, by the mind's own act. It may be presumed that every complete image thus formed is produced by combining objects already known and remembered. In the process of mental arithmetic above described, the mental "counters" appeared (in the writer's case) as whitish spots on a dark ground. In mental chess-playing there must be great diversity. It would be interesting to ascertain from Morphy, Blackburne, and the rest, what sort of mental boards and pieces they employ; for such masters of the art of blindfold play must see well-defined pictures,—chess boards and men which they could describe and could get made for them.* My own mental chess-board is ill-finished about the edges, and the men have shadowy supports which, as it were, elude me when I try to determine their character. Probably every reader of these lines has met with a similar difficulty in attempting to determine the exact nature of a mental image. For instance, the newspaper account of an accident states, let us say, that "several persons who were standing near" when an accident happened did so and so; on reading this you immediately have a mental image of several persons, but they are shadowy beings, and if you try to determine precisely what they are like, they become still more shadowy or vanish altogether. (But probably no two persons have the same experience in such matters)†

It may be questioned whether some remarkable feats of memory may not be explained by the power of forming mental pictures, though of course the power of recalling the sequences of sound must oftener be that on which the remembrance of long series of notes and numbers depends.

I am not free to discuss here the method by which my friend Professor Loisette supplies the means both for fixing

* I may mention here the story that Garrick once sat for another man's portrait. It need scarcely be said perhaps that the story is not strictly true. It was, however, based on a fact. The likeness of Fielding forming the frontispiece to Murphy's edition of Fielding's novels was drawn by Hogarth from memory after the novelist's death. "Being unable," Sturz says, "to call to mind some peculiar expression about the mouth, Garrick came to his aid by imitating it." In reality, the power of imitating some expression of another's countenance is a faculty well worth considering. It would be a matter of curious inquiry (in the scientific sense) to discuss why some persons are able to imitate almost any expression, while others with equal command of feature, when attempting to represent a particular expression, produce an expression which is totally different, though perhaps equally characteristic.

* Thus a Cerebral Museum might present as curiosities the board and men with which Morphy played such and such a game blindfold; the set of eight boards and men used by Blackburne in mental play on such and such an occasion. We have all heard of the sword exhibited as the one Balaam had in his hand when the ass addressed him (hallucinatory manifestation, no doubt), and how, when it was pointed out that he only wished for such a sword, the relic was described as "the very sword he wished for;" but, if I may say so without spoiling a good story, supposing Balaam had a clear mental idea of the sword with which he would have liked to kill that obnoxious ass, a sword constructed accordingly would be an interesting object to the student of mental phenomena.

† The "person" who makes his (or her) appearance in this case must have had, I suppose, some definite origin, but he (or she) is not easily identified. The mental "bystander" is a different being altogether. I have never been able to satisfy myself whether the "person" came out of books or pictures known to me in childhood, or had some real original. I half incline to think that *my* "person" is an imperfect mental image of a woman, a sort of nurse-housekeeper, who was the first person I knew much of outside the family circle. Something in the aspect of the mental person, when momentarily called up with unusual clearness, reminds me of that monitress of my childhood.

XUM

matters in the memory, and for giving the memory effective exercise. I am satisfied that apart from the use which I have repeatedly found for his method, in forming a mental tablet not easily erasable, of objects or details which I wish to bear in my mind, the use of the method in memorising by way of exercise strengthens the memory as effectively as a well-devised system of exercise for the limbs strengthens the body.

Passing to other methods (or to methods which have not been so specially suggested for memory-training), it is to be noted, in considering feats of memory relating to written or spoken words, that apart from artificial aids to memory, there are at least three ways in which memory may act:—

We may remember the facts, and may thus often recall the words also, especially if these are particularly appropriate or striking. Indeed, there are some passages which could hardly be recalled without the appropriate words, simply because no other words or arrangement of words would present the same ideas as well. For instance, the soliloquy in "Macbeth," beginning "If it were done, when 'tis done," &c., might be recalled word for word by one who had carefully noted the sequence of ideas, and also of course (as part of this way of remembering) the use of particular words and images. Every sentence brings in the next, and very little effort of memory is required to recall such peculiarities of expression as "trammel up the consequence," "with his surcease success," "the be-all and the end-all here," and so on. Some parts of the soliloquy in "Hamlet," beginning "To be, or not to be," might even be recalled by the incongruity of the images.* It is not probable that any of the more remarkable feats of memory recorded can be explained by the exercise of this method, which may be called *reasoning memory*, though this kind of memory is undoubtedly the most valuable, and perhaps the only kind necessarily indicating mental power, in the usual sense of the words.

(*To be concluded.*)

* It does not seem to us at all clear that the critics (from Voltaire downwards) who have abused Shakespeare for making Hamlet talk of taking "arms against a sea of troubles," are better justified than a moralist would be who should object to the reasoning of Iago. It is of course possible that Shakespeare wrote a careless line in this noble soliloquy. Johson tells us that Shakespeare, in extemporising on one occasion in the character of Julius Cæsar, brought out the amazing line, "Cæsar never doth wrong but with good cause." Extemporising and writing, however, are different matters; the line appears in the play as written—

> Know Cæsar doth not wrong; nor without cause
> Will he be satisfied;

and it seems on the whole safer to consider that Shakespeare had some idea what he was writing when he created the soliloquies of Hamlet. The point is to some degree connected with the question—about which so much has been written to so little purpose—whether Shakespeare intended to present Hamlet as really insane, at least from the time of the interview with the Ghost. Though this seems untenable, yet in all the later soliloquies (which really determine the point) there is manifest evidence of mental disturbance, whereas only a certain perturbation of spirit is shown in the soliloquy of the second scene. Shakespeare's purpose seems so clear that one wonders how anyone can mistake it. Hamlet's pretended madness was first thought of, where Hamlet says,

> How strange or odd soe'er I bear myself,
> As I, perchance, hereafter shall think meet
> To put an antic disposition on.

This was too soon after the interview with the Ghost to be regarded as a deliberately adopted plan. Manifestly it was intended at first merely to account to his friends for "the wild and whirling words" he had just used: he is beginning to recover himself, and perceives how strange his behaviour must seem to Horatio and Marcellus. As the scene closes, his wildness has given place to settled despair. We have said that the soliloquies decide the question of Shakespeare's real intention—if a true poet can be said to weigh such matters. (We know how Richter said, "A poet who doubts whether a character shall say this or that, to the devil with him." The soliloquy following the interview with the Ghost is specially decisive of the state of Hamlet's mind *then*. Who but one half-crazed for the moment would have thought of jotting down a note about the smiling of villains, just after he had heard of his father's murder, and from his father's ghost?

Letters.

[The Editor does not hold himself responsible for the opinions or statements of correspondents.]

MR. INWARDS'S COMPENSATED PENDULUM.

To the Editor of KNOWLEDGE.

SIR,—I am glad to hear that KNOWLEDGE again wishes to encourage correspondence, besides other announcements which I was glad of; though I am far from considering anything of that kind a compensation for the melancholy loss of its original editor, in whose career I always took a warm interest, from my first acquaintance with him at the R.A.S. many years ago. He has left no such writer behind him.

I have only just received the full description in the R.A.S. *Monthly Notices* of the compensated pendulum proposed by Mr. Inwards at the November meeting, and I find it resembles, even more than I supposed from the shorter account I had seen of it, one that was described in the first edition of my book on Clocks in 1850. His principle of construction is described thus:—"About the middle of the length of the pendulum spring it is grasped by a clip, consisting of two arms, which are adjusted to embrace it with sufficient closeness to hold it firmly, but loose enough to allow movement in a vertical direction." And then he describes how the clips are made to rise and fall as the temperature falls and rises and the pendulum rod contracts and expands, by attaching them to a block sliding between fixed cheeks, and pulled up and down by steel and zinc compensation rods, with a good deal of machinery compared with an ordinary zinc and steel pendulum.

I see that on p. 92 of my first edition I described, first, the plan, which Mr. Inwards rightly mentions as an old one, of the "pendulum top" (as clockmakers call the piece which holds the top of the spring) being raised while the clipping chops are fixed, but lets the spring run through them. Then I proceeded: "The same object might be effected in another way, and with several incidental advantages, provided the objection I shall mention can be removed. Let the pendulum be hung from a fixed cock, as usual. . . . A cast-iron lever rests on pivots in a cock fixed firmly to the wall. At one end is a wire or rod of the same length and material as the pendulum (assuming the arms of the lever to be equal). The lower end of it passes through a cock on a level with the bob or centre of oscillation, with a nut for adjustment. The other end of the lever is so made as to clip the pendulum spring, but not so tightly that it cannot move under pressure, which is supplied by a weight at that end, so as to keep the compensation wire tight. Then, as the pendulum rod lengthens under heat, the compensating wire lengthens too, and lets the weight pull down the clipping chops, and so keeps the effective length equal. As the motion would not be a twentieth of an inch for 40 degrees of heat in a 2 sec. pendulum, it is of no consequence that the motion is in a circular arc theoretically, for the versed sine of such an arc would be quite insensible."

Then comes the rather serious objection to all this class of contrivances, "that any alteration of the length of the spring is found to affect the rate, not uniformly, but in some variable way which is not reducible to any fixed law, so far

as is known." That conclusion I derived from the best practical information I could get, and the notorious fact that Harrison's original method of compensating watches by sliding pins on a compound or compensating bar, embracing the spring, had been found so defective that after Earnshaw invented the compensation balance the other method went completely out of use. And I see, further, that having once described that class of inventions, both other people's and my own, I did not think it worth while to repeat them in any of the later editions of the book, though mine, at any rate, had the advantage of requiring no other metal besides the single one of the pendulum rod.

It is a small matter, but a matter of fact, that Mr. Inwards is wrong in saying that "in the Westminster clock, on at least two occasions, pieces of metal had to be inserted to bring the compensation to its present apparently perfect condition." None were ever inserted during all the time that it was under my jurisdiction, or while I used to hear of all that was done to the clock from Dent's old foreman who made it under me, and died lately at the age of eighty-six, and was in full vigour nearly till his end. The right way for a pendulum of any new size is to take care to start with a zinc tube a little too long according to calculation, and reduce it by trial gradually if necessary. We only had to alter the Westminster zinc tube once. For some reason or other the previous length at the Royal Exchange clock did not come quite right for this heavier pendulum. The actual lengths are all given in the later editions of my book, and a good deal more about various compensations.

December 15. GRIMTHORPE.

THE SOCIETY OF AMATEUR GEOLOGISTS.

To the Editor of KNOWLEDGE.

SIR,—Will you permit me to add a small supplement to Mr. W. Jerome Harrison's paper on "Geology in London"? Under the head of Scientific Societies founded for the study of geology, he gives an excellent account of the Geological Society and the Geologists' Association, but he was probably not aware that London has a third body for the study and dissemination of geological knowledge.

The Society of Amateur Geologists was founded four years ago, and holds evening meetings on the third Friday in the month (except July and August), at 10 Arthur Street West, London Bridge. Excursions are made on Saturday afternoons to places of geological interest around London, when all the members have ample opportunity of questioning the directors.

Professor G. S. Boulger, F.L.S., F.G.S., is president. The annual subscription is 7*s.* 6*d.*

Though it does not rival the older Societies in numbers, it offers many advantages to amateurs, which more important bodies are necessarily without. In the presence of smaller numbers less hesitation is felt in taking part in a discussion, and in reading a first paper; and thus an amateur, by degrees, obtains confidence and becomes better qualified to take an active part in larger Societies. The place of meeting, being in the City, is convenient to those residing in the southern and eastern parts of London.

W. J. ATKINSON, Hon. Sec.

76 Christchurch Road, Streatham Hill, S.W.:
December 10, 1888.

AN UNDECIPHERABLE CIPHER.

To the Editor of KNOWLEDGE.

SIR,—Your readers may be interested in the following cipher, which is much simpler than the complicated cipher proposed by Mr. Proctor in the July number of KNOWLEDGE, or that suggested by your correspondent, Mr. Anderson, and published in the November number, and it seems to me to be equally undecipherable in the absence of the key. It is so simple that I can hardly credit that the method I suggest has not been made use of already, but after making some inquiries I have been unable to find any one who has heard of it. A key number is selected, consisting of any number of figures that may be preferred, say, for example, the number 253.

Suppose the sentence to be written in cipher is—"The rolling stone gathers no moss." The key number should be written continuously under the sentence thus—

The rolling stone gathers no moss.
253 2532532 53253 2532532 53 2532

Then rewrite for each letter another letter of the alphabet, as many places further on in the ordinary alphabetical order as the number underneath it. Thus in the sentence above, in dealing with the first word, *the*—

t will become *v*, being 2 places further on in the alphabet,
h „ „ *m* „ 5 „ „ „
e „ „ *h* „ 3 „ „ „

and so on throughout the whole of the words, and the entire sentence will read as follows:—

vmh ttomnqi xwqsh ifwjjuu sr otvu

This may be written either with spaces between the words, or continuously. It will at once be seen how absolutely impossible of solution this cipher is by the ordinary methods, for in the second word *ttonnqi* the two *t*'s represent different letters in the original, as also do the two *n*'s, and in the fourth word, *ifwjjuu*, the *j*'s and *u*'s are also representative of different letters in the original.

Shortly put, the would-be decipherer must guess the number thought of without even being told of how many figures it consists, and as the number of combinations of figures is infinite, it would be waste of time to try to solve such a cipher even by trying one key number after another.

As a long key number may be desired, and it is not easy for every one to remember a lengthened series of figures, a simple method would be to have a key word from which the key number is obtainable, by substituting for each letter its numerical place in the alphabet. Thus, suppose the key word to be "boz," the key number would be 2, 15, 26, or if preferred, 21526 as a key number of 5 figures. Similarly with longer words, or even sentences.

The letters of the alphabet must be considered as forming a continuous band—*a* following *z*. Thus the number 3 written under *y* would read as *b*. A simple instrument for facilitating the reading and writing of such messages might be devised, consisting of two concentric circular discs, with the letters of the alphabet printed round the circumference of each. The discs might be rapidly displaced on one another by means of a central knob, with an index pointing to a circle of numbers on the smaller disc, and the superposed letters of the alphabet would then correspond to the displacing number.

ARTHUR BOVELL.

CROSS-FERTILISATION OF WHEAT.

To the Editor of KNOWLEDGE.

DEAR SIR,—In the charming and most instructive papers in former numbers of KNOWLEDGE, Mr. Grant Allen has often pointed out the advantages to plants of cross-fertilisation, and the devices which several distinct orders of plants have adopted to avoid the evil effects of self-fertilisation. A common contrivance among wind-fertilised plants is that of the anthers ripening at a different period to the stigmas. My object in alluding to the matter is to inquire if any such or similar device is known to be practised by the grasses, and especially by the wheat plant. This inquiry has been suggested by noticing the well "set" (with

grain) spikelets of some ears of wheat in a crop in which two or three varieties of wheat were growing together. Would the fact that the stamens of this plant hanging pendulously in the wind imply that there is an attempt at cross-fertilisation of the individual florets of one spikelet with the florets on other parts of the same head, if not between the flowers of separate plants? For instance, in a specimen of black foxtail (*A. nigra*) lying before me the anthers of the upper portion are pendulous while the anthers of the lower portion are only just showing themselves—being much shorter than the stigma—as if the action of gravity were taken advantage of in fertilising the stigmas of the lower florets. But not being a scientific expert, I do not feel myself qualified to decide what is the most advantageous union between the sexual organs of the wheat plant.

The question, to put it shortly, is:—Is the pollen of any floret prepotent in fertilising the ovary of that floret to the wind-wafted pollen? If the floret is self-fertilising, why do the stamens hang pendulously?

If some of your correspondents would answer this question it might interest others beside A FARMER.

COMETS.

To the Editor of KNOWLEDGE.

SIR,—Allow me to congratulate you on your being enabled to continue the publication with a number of very interesting articles, the continuance of which in future numbers ought to insure you success in your undertaking.

In the article headed "How Comets Come to Us," in the December number, Mr. A. C. Ranyard, in reference to Comet *e* (1888), says:—"But the velocity with which these comets move is so little above the velocity which they would acquire by the action of gravity in falling towards the sun, that the time which they must occupy in traversing the inter-stellar spaces is altogether inconceivable by the human mind." How, without a knowledge of the mass or density of these comets, and in ignorance of the projective force communicated to them at "a distant part of space" towards our system, does Mr. Ranyard arrive at his conclusion? It appears to me that the problem is insurmountable, and that a comet, or any other body, falling towards the sun by gravity alone, or gravity *plus* an initial projective force, must inevitably be precipitated upon the sun, for both forces would combine to carry the comet in a straight line towards the sun. HENRY J. MADGE.

Swansea: December 1888.

HOW COMETS COME TO US.

By A. COWPER RANYARD.

I HAVE received several letters with reference to my short article in the last number under the above heading. It is evident that considerable interest is felt in the question of the sun's connection with comets moving in parabolic orbits.

It cannot be doubted that a large proportion of the comets discovered, do move in such orbits, that is to say, they either move in ellipses which are so long that they cannot be distinguished from parabolas, or they move in hyperbolic orbits which differ so slightly from parabolas in the part of the orbit in which the comet remains visible that the predicted places calculated on the assumption that the orbit is parabolic, correspond with the observed places within probable limits of error of observation.

Comets to which hyperbolic orbits have been assigned are very rare, and I ought to mention that since last month I have received a letter from Dr. Copeland in which he states that he is now doubtful whether Comet *e* is moving in such a hyperbolic orbit. He says: "It turns out that the Mount Hamilton observation of September 2 is unfortunately about 14″ wrong in declination. This upsets Dr. Becker's computation a good deal. However, he has now collected and compared a large number of observations, and is working out fresh elements about which you shall hear before long." Among older comets to which hyperbolic orbits have been assigned there is no case in which the eccentricity differs more than a few hundredths from Unity, and I am probably within the mark in saying that none of them can have been moving with a velocity of two miles a second above the velocity they would have acquired in falling towards the sun from rest at an infinite distance. But the sun is moving through space with a velocity which may be safely assumed to be more than two miles per second. The velocity usually accepted—1·623 radii of the terrestrial orbit per annum—corresponds to more than $4\frac{3}{4}$ miles per second, a velocity which no doubt depends on some rather doubtful assumptions with regard to the average parallax of stars of the first magnitude, but probably few astronomers would venture to place it as low as two miles per second.

Many of the stars are certainly moving with much greater velocities than this relatively to the sun. And if we adopt the theory that comets have been ejected from such stars, they would participate in their proper motion, and have large relative velocities with respect to the sun. In other words, such comets would not move in parabolic orbits.

How, then, can we account for so few comets approaching us with velocities greatly above the velocity they would have obtained in falling, under the influence of solar gravity, from rest, or rather relative rest, with respect to the sun at an infinite distance. It must be remembered that we can only observe comets which have small perihelion distances—that is, perihelion distances usually considerably less than the radius of the orbit of Jupiter. Beyond that distance the sun's heat does not raise a tail or sufficient nebulous envelope to render them visible. Of the comets which approach from stellar distances, only those which have very small initial motions at right angles to the radius vector can be observed by us. And the observed orbits show that the initial velocities in the direction of the radius vector are also small; that is, the comets observed by us must have been originally moving approximately in the same direction and with the same velocity as the sun in space.

It will be seen that I do not adopt Dr. Hoek's theory that the comets whose aphelia lie in the neighbourhood of bright stars were probably ejected from those stars. The facts as to the grouping of cometary aphelia in certain directions to which Dr. Hoek drew attention, only prove that certain families of comets approach the sun in similar directions, and were near together when at a great distance from us; the proper motions of the stars would have carried them far away from the positions of the cometary aphelia long before the comets could reach the solar system. Thus, if a star had a uniform proper motion of $\frac{1}{25}$th of a second per annum, it would be carried through 180° upon the heavens in 16,000,000 years.

With reference to Mr. Madge's difficulty it is evident that the weight of a comet may be neglected in calculating its orbit, for two comets, each weighing a ton, would be similarly acted upon by the sun, and would move together. That is, they would move in the same manner as a comet weighing two tons. Similarly for all other multiples. A

comet moving directly towards the sun would undoubtedly fall into it. It is evident, therefore, that there must have been some initial velocity in a direction at right angles to the radius vector in the case of all comets which clear the sun, and no comet has yet been known to plunge into the sun.

Notes.

Dr. Ralph Copeland, Ph.Doc., F.R.A.S, has been appointed Astronomer Royal for Scotland, and Professor of Practical Astronomy in the University of Edinburgh, in the place of Professor Piazzi Smyth, who resigned some months since. We heartily congratulate the University of Edinburgh on the appointment.

Mrs. Proctor desires us to return her thanks to the numerous readers of KNOWLEDGE who wrote expressing their sympathy with her in her loss. Mrs. Proctor has now returned to America. The article on "Fairies" published in the November number, and signed Mary Proctor, was by Mr. Proctor's eldest daughter. All Mr. Proctor's children with the exception of one little boy are now in America.

Excellent results are said to have been obtained lately with a submarine boat at Toulon called *la Gymnote*. Its movements can be varied at will in direction and depth, like those of a fish; and it can be easily kept at a given depth. A speed of 9 to 10 knots can be obtained. The lighting is good and respiration is easy. The normal crew is three men, but at its first trial it contained five, including some high officials of the French navy. The first immersion lasted twenty minutes, and the second three-quarters of an hour. The motor force is electricity, but some details of the system are at present a secret.—*Revue Scientifique.*

A large number of infants, estimated by M. Brochard at 100,000, by M. Roussel at 150,000, die annually in France from hunger, neglect, and like preventable cases. And the evil seems to be growing. Thus, the death-rate of infants of the first year, which was 15·9 per cent. in 1840-44, is now about 26 per cent. It varies greatly in different departments. In Paris it is 29 per cent.

In a paper read by Professor Pohlman before the American Institute of Mining Engineers, and entitled "The Life History of the Niagara Falls," the first historical picture of the Falls is stated to have been given by Father Hennepin in 1678. Then the Horseshoe Fall was not as far away from the American Fall as now. The American Fall then had the shape of a horseshoe. From 1841 to 1886, according to Professor Pohlman, the Horseshoe Fall has receded 485 feet in the forty-five years from 1841 to 1886, and it is now going back at the rate of about 9 feet a year.

At the French biological station of Banyuls, on the Mediterranean, they have been lately applying the electric light to the observation of marine animals, with interesting results. The light from an arc lamp is thrown laterally into a tank about 5 feet long, and the observer looks across it, sometimes using lenses by which details of organisation, not otherwise visible, can be seen, for example, in polypes &c., embryos are revealed swimming in the bodies of their parents. Tissues which contract and expand largely are much better understood than in the preserved state. The animals seem to have proved not so impressionable to strong light as was expected. The fishes were at first surprised, and came slowly towards the light, but did not remain there persistently. Some annelids contracted a little on the light entering; and a number of sea-anemones, which at night covered the sandy bottom with their tentacles, did not retract these under the electric light. It is found, however, that once acclimatised in these tanks, animals lose a good deal of their impressionability.—*Comptes Rendus.*

BOULAK MUSEUM.

The *Athenæum* says that on December 8 last the ground and buildings of the Boulak Museum, together with the director's house, were to have been put up for sale by auction. The purchaser is to take possession of the house in six months, and of the museum buildings twelve months later. It has been decided to remove this collection into the palace of Ghizeh, a transfer that will involve visitors to the museum and students in considerable expense for carriage hire from and back to Cairo. The director's house was built but two years since, and it is felt that the British officials at Cairo are in a measure responsible for this change, which the *Athenæum* considers very undesirable. On the other hand, the present site of the museum is on low ground, near to the river, which is always liable to be inundated by the Nile when high. The dampness of the present situation is shown by the way in which wooden objects from the dry regions of Upper Egypt have expanded with damp and cracked on drying again, causing irreparable injury.

JAPANESE LACQUER FOR IRON.

A fresh use has been found for the well-known Japanese gum lacquer, a modification of which has, after many experiments, been adopted for the imperial Japanese navy. There is some difference between the compound as prepared for painting iron and steel and the ordinary lacquer employed for wood, the inventor of the new composition having had great difficulty in conquering the tendency of this material to get very hard and then crack. Experience has shown that a ship protected with this variety of lacquer has been able to keep afloat in tropical seas for three years, going into dry-dock only once instead of six times during that period as usual. It is consequently thought that at last a tolerably perfect anti-corrosive coating for iron and steel structures has been discovered, which may render useful service in the preservation of all kinds of structures in these metals.—*Iron.*

THE DISCOVERER OF HYDROGEN.

In the *Revue Scientifique* of November 24 last, M. Emile Meyerson gives an interesting account of Theodore Turquet de Mayerne and his initial experiments with sulphur of mercury—"Æthiops Turqueti"—benzoic acid, and hydrogen. Turquet, born September 28, 1573, was son of Louis Turquet, a native of Lyons, who, to avoid the persecution of Huguenots, had sought refuge in Geneva in the preceding year. After passing some years in Heidelberg University, Theodore went to Montpelier, where he proceeded to the degree of doctor of medicine on February 20, 1597. Settling in Paris, and nominated a king's physician, he had a prosperous career before him which, however, was frustrated by the combined action of the faculty, owing to his adherence to the ideas of Paracelsus, and eventually drove him out of France. On September 25, 1603, a decree appeared prohibiting all doctors from meeting him in consultation. In 1611, having lost a good friend by the assassination of Henri Quatre, he came to England, where he was cordially received by the leading members of his profession as well as by the King, who knighted him in 1625. On James I.'s death he found equal favour at the Court of Charles I. and his French consort. He died at Chelsea on March 16, 1655, having received the empty honour of physician to Charles II.

XUM

THE GREAT NEBULA IN THE PLEIADES.

By A. COWPER RANYARD.

THE little group of stars in the constellation of the Bull, known as the Pleiades, has attracted the attention of star-gazers from the time of Job.

Keen eyes on clear nights could just catch sight of seven stars, a mystic number which perhaps had something to do with "the sweet influences" which this group of little stars were supposed to possess.* From the time of the invention of the telescope by Galileo in 1609 to the present day, successive observers have counted more and more stars in the cluster as the telescopes at their disposal have improved. But with the exception of a doubtful observation of a nebula in the group by Jeaurat in 1786 (a nebula which he only entered on a map and did not draw), no observer noted any nebulous matter in the Pleiades group till Tempel, an Italian astronomer, in 1859 produced a drawing showing a faint nebulous haze of considerable size just enveloping the star *Merope* and stretching southward to a distance of half a degree. His drawing is published in No. V. of the publications of the Milan Observatory, and represents the nebula as a comet-like mass, having *Merope* for its nucleus. The names of some of the brighter Pleiades may be useful for reference; they are written below in positions corresponding to their places on the map.

The existence of the nebula remained doubtful until the beginning of 1886, when the brothers Henry obtained photographic plates showing some traces of the nebula, but not nearly as much as is shown in the drawing on the opposite page.

Up till that time the observers who could see the nebula differed amongst themselves as to its form, and some equally excellent observers maintained that they had frequently examined the group with first-class instruments, and could detect no glimmer of nebulous light about the larger stars or around the group.

The observations are worth examining, as they throw some light on the differences which are always likely to exist when observations are pushed into the border-land of vision, where by reason of the extreme faintness or minuteness of the objects examined, the eye begins to fail, and the imagination begins to play a larger and larger part in filling up the gaps where the senses of the eye-straining observer fail him.

Perhaps the differences between some of the keen-eyed observers who searched for this nebula may be accounted for by the fact that, when searching for an area of very faint luminosity, it is necessary to use a suitable power which just admits the whole pencil of light from the object glass or speculum of the telescope into the expanded pupil of the eye, so that in order to obtain the maximum of success with a particular instrument, the observer should measure the diameter of the pupil of his eye under the stimulus of very faint light, and should select an eye-piece which would probably fail to give him the best results in examining close double stars or difficult planetary markings.

Peters, Chacornac, Schmidt, Schönfeld, Auwers, and some others succeeded in observing Tempel's nebula, some of them with small telescopes. D'Arrest and Schjellerup failed to see it with the large refractor at Copenhagen. D'Arrest suggested that the nebula might be variable, and the belief appears to have become somewhat general. Goldschmidt, the French artist who discovered so many small planets, observing in 1864, thought that the entire group was surrounded with nebulous matter, extending over an area of 5°, but with a dark space in the portion occupied by the brighter stars similar to the dark space which appears to surround the trapezium in the Orion nebula, an observation which has by no means been confirmed by the photographs, so far as the regions about the bright stars are concerned.

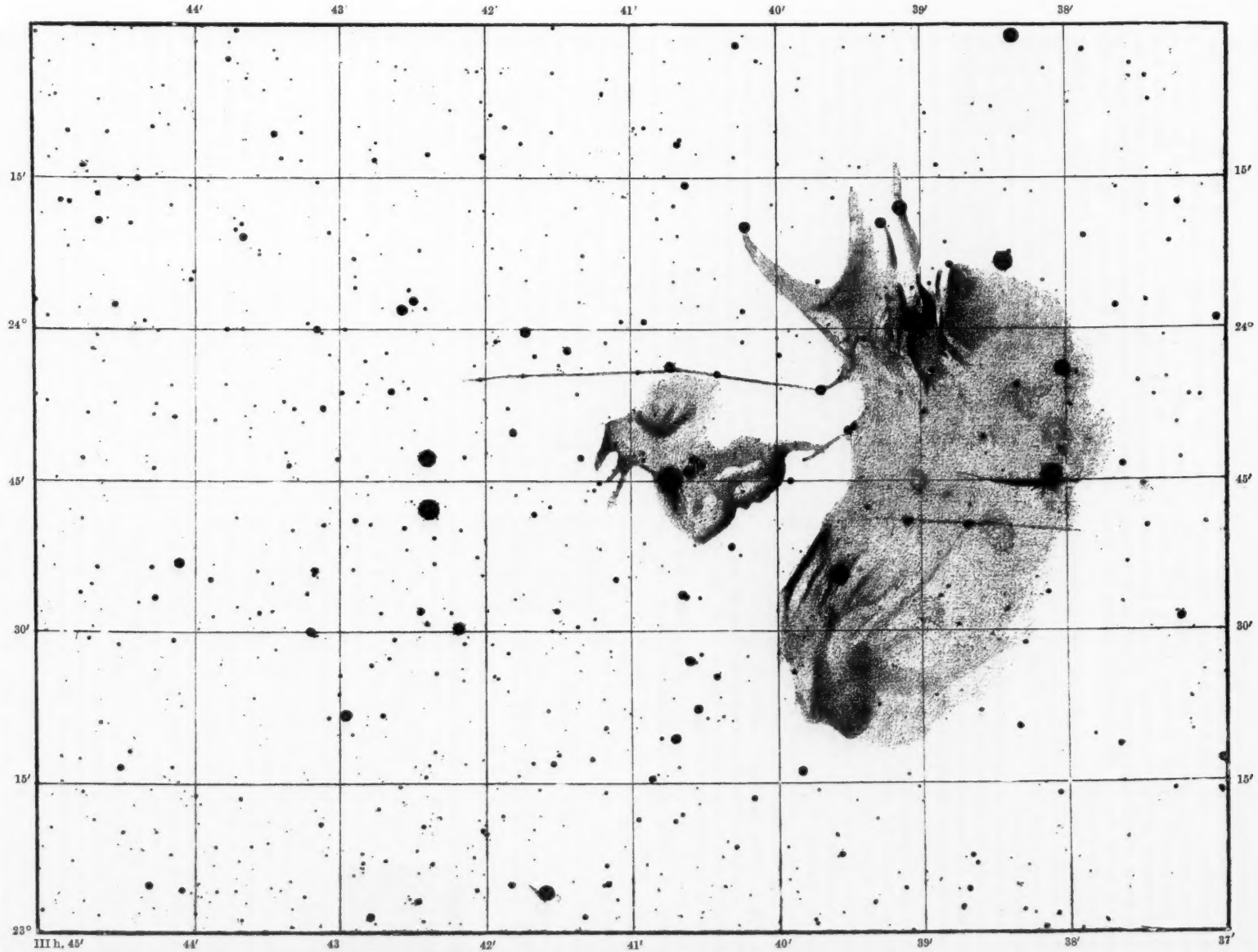
M. Wolf, in his elaborate memoir on the Pleiades in the "Annals of the Paris Observatory," vol. xiv., substantially agrees with Goldschmidt in this respect. His drawing shows the Merope nebula, but its northern boundary has a different curvature from Tempel's, and it is of greater extent, especially on the preceding side. In these respects Wolf was confirmed by Schiaparelli in 1875, and by Maxwell Hall in 1880. Amongst the observers who detected the Merope nebula should also be mentioned the Rev. T. W. Webb, who saw it with a 5½-inch achromatic in 1863, and drew it afterwards with a 9½-inch speculum very much as it is shown in the drawing of Tempel.

In 1880 Mr. Common published, in the *Monthly Notices of the Royal Astronomical Society*, a sketch of the Pleiades made with his 3-foot reflector, differing entirely from any previous drawing. He gives three distinct nebular masses, one of them, a long mass near Merope, evidently corresponding with the brightest of the streaks whose existence is now confirmed by the photographs. The most contradictory evidence with regard to the Merope nebula was that of Professor Hough and Mr. Burnham, whose marvellously keen eye has detected the duplicity of far more double stars than any other observer. In 1880 and 1881 they searched for it with the greatest care with the 18½ inch refractor of the Chicago Observatory, but entirely in vain, and they were so certain of its non-existence, that they suggested that it might be due to some kind of optical illusion due to the light of the stars in the neighbourhood. Lewis Swift, the American comet discoverer, picked it up in 1874, Pratt in 1876, and Backhouse in 1882.

The whole question remained in this uncertain condition till the beginning of 1886, when the brothers Henry, of the Paris Observatory, took some photographs of the Pleiades with their 13-inch refractor, giving exposures of three hours' duration. In the 1886 photographs four nearly parallel streaks near Merope are shown, as well as the curious curved arms of light which stretch away from Maïa and Electra.

On October 23, 1886, Mr. Isaac Roberts, of Maghull, near Liverpool, obtained a photograph in 1h. 29m., which shows about the same amount of nebula as is to be traced on the earlier Henry photographs. Later in the year he obtained two other photographs, each with three hours' exposure, which show great nebulous masses around Maïa and Merope, and curious detached masses about Alcyone and Electra, as well as the long string of nebulous light threading the stars to the north of Alcyone.

* "Canst thou bind the sweet influences of Pleiades?" (Job xxxviii. 31) is, I take it, a poetic way of saying, Canst thou stop the rotation of the vault of heaven, and keep the lucky little group of seven stars in the ascendant for any time you may desire to be fortunate.



THE GREAT NEBULA IN THE PLEIADES.
As shown upon photographs taken by the Brothers Henry at the Paris Observatory with an exposure of four hours.

The nebula, shown in the engraving which has been very carefully prepared for me by Mr. W. H. Wesley from a steel plate published in the report of the Paris Observatory, shows the wonderful nebulous structure, which has since been photographed by the brothers Henry with their 13-inch refractor, giving the photographic film an exposure of four hours, with the aid of most accurate clock-driving, controlled by the eye of the observer watching the stars through a twin-telescope.

The contrast between the nebula and the background of sky is somewhat too sharp on the plate as compared with the photographs, but the structure of the nebula has been very carefully copied.

It will be noticed that there are two nearly parallel narrow streaks of nebulous light which thread stars, the one lying to the north of Alcyone, and the other also running east and west between Electra and Merope. There is a general parallelism between these two streaks and the arm of light which curves away eastward from Electra. Neither streak of nebulous matter is perfectly straight, and they do not accurately thread the centres of the stars which lie along their course, but one can hardly doubt that there must be some connection between the stars and the streaks, and that the position of the stars in connection with the streaks is not a mere matter of accident. It will be noticed that there is a curious stream of stars in the line of the upper streak prolonged eastward. There is also a curious parallelism about the streaks near Merope and the detached masses further north, as well as about the structure in the neighbourhood of Maïa.

We are very far at present from understanding the meaning of these great physical facts, but they are eminently worthy of study, and they no doubt contain secrets with respect to the construction of the stellar universe which will some day be read or partly guessed by man.

THE FACE OF THE SKY FOR JANUARY.

BY HERBERT SADLER, F.R.A.S.

THE paucity of sun-spots still continues. There will be a total eclipse of the sun on the 1st of the month—not, however, visible in England. The eclipse begins at four minutes past seven, G.M.T., on the morning of the 1st in longitude 179° 54′ west of Greenwich, and latitude 31° 35′ north, the greatest eclipse being in 137° 58′ west longitude, and 36° 44′ north latitude; the eclipse ends in 95° 54′ west longitude, and 30° 36′ north latitude, at 11h. 30m., G.M.T. The greatest duration of totality is 2 min. 1 sec. The Lick Observatory is situated south of the central line, but an expedition will be sent from there to observe the total phase. Conveniently observable minima of Algol take place at 9h. 35m. on the evening of the 1st; at 6h. 24m. on the evening of the 4th; at 8h. 6m. on the evening of the 24th; and at 4h. 55m. on the afternoon of the 27th. Mercury will be very unfavourably situated for observation during the first part of the month, but comes into a better position towards the end of it. On the last day of the month he sets at 6h. 32m. P.M., or more than an hour and three-quarters after the sun. Venus is becoming a conspicuous object in the evening sky, her diameter on the last day of the month subtending an angle of over 20″ of arc. On that evening she sets five hours and twenty-two minutes after the sun. Mars is invisible, and Jupiter rises on the 1st of the month at 6h. 49m. A.M., his declination being 22° 51′ south. Saturn is well situated for observation, though his ring system is now visibly closing up. He rises on the 1st at 7h. 13m. P.M. He describes a short retrograde path through a barren region of Leo. Uranus still rises too late to be picked up by the ordinary amateur. Barnard's first comet is rapidly diminishing in brightness, though at the beginning of December this comet was distinctly visible to the naked eye, and had a tail nearly 1° in length. The orbit seems to be an ellipse, and not a hyperbola. The Quadrantids are the most notable shower of shooting stars observable during the month, the radiant point being in AR 15h. 12m., and 53° north declination, the greatest display being visible during the morning hours of January 1 to 3. There will be a partial eclipse of the moon, partly visible at Greenwich, on the morning of January 7. The first contact with the penumbra takes place at 2h. 40m. A.M., and the first contact with the shadow at one minute to four. The middle of the eclipse is at 5h. 30m. A.M., the last contact with the shadow at 7h. A.M., and with the penumbra at 8h. 20m. A.M., when the moon will have set at Greenwich. The magnitude of the eclipse is $\frac{7}{10}$ths of the lunar diameter. On January 10 the 4th magnitude star μ Ceti will suffer occultation at 6h. 52m. A.M. at an angle of 107° from the vertex, the reappearance taking place at 8h. 15m. at an angle of 315° from the vertex. δ^2 Tauri will be occulted at 10h. 21m. on the evening of the 12th, the disappearance taking place at an angle of 155° from the vertex; the reappearance occurs at 11h. 32m. at an angle of 291° from the vertex. At 2h. 34m. A.M. on the morning of the 14th the 6½ magnitude star B.A.C. 1651 will disappear at an angle of 140° from the vertex, and will reappear at 3h. 36m. A.M. on the same morning at an angle of 308° from the vertex. At 4h. 32m. on the evening of the same day χ' Orionis will make a near approach to the lunar limb at an angle of 331° from the vertex, and on the evening of the 17th 35 Cancri will approach at an angle of 137° from the vertex. 8 Leonis will be occulted at 10h. 49m. on the evening of the 18th at an angle of 51° from the vertex, the reappearance taking place at 4m. past midnight at an angle of 221°. On the 25th ξ' Libræ will approach at an angle of 140° from the vertex at 5h. 12m. A.M.; on the 26th θ Libræ will be occulted at 6h. 36m. A.M. at an angle of 91° from the vertex, the reappearance occurring at 7h. 39m. A.M. at an angle of 219°, and on the morning of the 27th the 6½ magnitude star B.A.C. 5663 will be occulted at 7h. 9m. A.M. at an angle of 358° from the vertex, the reappearance taking place at 7h. 41m. at an angle of 309°.

A NEW PAVEMENT.

Herr Busse, of Linde, is introducing in several towns of Germany the use of indiarubber for paving streets. He laid down such a pavement for the first time in 1887, on the Goethe Bridge, in Hanover, which has a surface of 1,000 square metres, or 10,764 square feet. The new pavement, it is stated, proved so satisfactory, that 1,500 square metres (16,146 square feet) of ordinary carriage road in the city were laid in indiarubber last summer. The Berlin Corporation, having apparently satisfied itself of the value of the new pavement, have had a large area on the Lützow-Ufer paved with indiarubber, as an experiment, and the magistracy of Hamburg is likewise trying the experiment. It is asserted that the new pavement combines the elasticity of indiarubber with the resistance of stone. It is also said to be perfectly noiseless, not affected either by heat or cold, and not so slippery as asphalte.—*Builder.*

Our Chess Column.

BY I. GUNSBERG (MEPHISTO).

[Contributions of general interest to chess players are invited. Mr. Gunsberg will be pleased to give his opinion on any matter submitted for his decision.]

THERE are many positions in the openings which enable an experienced player to get an advantage by what for convenience sake we may call tricky play, but which is merely the result of his experience in former games where a similar position occurred. Some of these positions occur very frequently, and the combinations through which such positions are turned to good account are very obvious and easily pointed out, and if proper attention be given to the explanation, they should be remembered with great benefit to the player. The weakest point in the game is the King's Bishop's Pawn. Most attacks in the openings are directed towards it. If Pawn and move is conceded, the KBP is removed. One of the most frequently occurring dodges is to take this Pawn when the opponent's QB pins the Queen's Knight, enabling the player to win back his piece by discovered check, and remain a Pawn ahead, i.e. 1. P to K4, P to K4; 2. P to KB4, P to Q3; 3. Kt to KB3, B to Kt5; 4. P × P, P × P. 5. B to B4. Now if Black plays, for instance, B to B4, White wins a Pawn by replying 6B × P (ch), and if K × B, then 7Kt × P (ch), and winning back his piece with advantage. It must not be supposed that this position only arises in connection with this opening alone, nor that this is the only position where the sacrifice of the B on KB7 is possible. Opportunities for this sacrifice may occur in almost every opening, but by remembering the general idea, a player may avoid falling in the trap in whatever position it may occur. Experience consists of nothing else but the capacity for recollecting either by memory or instinct the features peculiar to every position. Even some of the finest players often suffer through a lapse of memory in this direction. Thus, for instance, Schallopp lost a game to Thorold at Hereford, through a manœuvre based on the above idea, and the fact of not recollecting for the moment this simple danger cost Schallopp the first prize, which otherwise he would have won, and the loss of the very substantial sum in prize money of 42*l*.

With B × P, an early mate may sometimes be brought about, also arising through the pinning of the King's Knight by B to Kt5, which, as may be seen, is a move requiring careful consideration at any time, not only whilst the move is actually made, but for the whole time the Bishops remain in that position, i.e., 1. P to K4, P to K4; 2. Kt to KB3, Kt to QB3; 3. B to B4, P to Q3; 4. Kt to B3, B to Kt5; 5. B to B4. We again repeat that we only wish to illustrate the idea so that it shall be thoroughly grasped independent of any position in which it may occur. For that purpose it will suffice to point out that if Black now plays 5. . . . Kt to Q5, White could reply 6. Kt × KP; and if Black play 6. . . . B × Q, then follows 7. B × P (ch), K to K2, 8. Kt to Q5 mate.

All that is requisite is to thoroughly impress these two ideas on the mind of the reader, and he should be able to avoid falling a victim to these positions in whatever guise or form they may occur. As an amusing illustration of the variety of attacks possible in consequence of the above idea of mating, we give the following game, which was one of fourteen games played simultaneously at the Jewish Chess Club, and although thoroughly unsound it will show the danger to be avoided.

WHITE. I. Gunsberg.	BLACK. Amateur.
1. P to K4	1. P to K4
2. P to KB4	2. P to Q3
3. Kt to KB3	3. B to Kt5
4. B to B4	4. QKt to B3
5. Kt to B3	5. Kt to B3
6. Castles	6. P to KR3
7. P × P	7. QKt × P
8. Kt × Kt	

Here, then, we again have the same idea in a much altered position, further complicated by the commanding position of the White KR in the open Bishop's file. The sacrifice is, however, unsound, as Black may safely take the Queen. If Black does not capture the Queen, but plays P × Kt, then White would equally reply with 9. B × P (ch); and in reply to K × B he can, of course, play 10. Q × B, and here is where the Rook comes in by pinning the Knight. But if, in reply to 8. . . . P × Kt, 9. B × P (ch), Black plays K to K2, threatening K × B after the White Queen moves, then 10. Kt to Q5 (ch) follows.

The game continued—

	8. B × Q
9. B × P (ch)	9. K to K2
10. R × Kt	

pursuing the same tricky but desperate course. If now P × R, 11. Kt to Q5 mate,

	10. K × R

This promises another piece to Black, and is just what the single player expected. A safe line of play was 10. P × Kt, if 11. Kt to Q5 (ch), Q × Kt. 12. P × Q, K × R, &c.

11. Kt to Q5 (ch)	11. K × Kt
12. P to Q3	

threatening perpetual check on B4 and K3.

	12. Q to R5

Not at all amiss.

13. B to Q2	

Defending the mate, and threatening a mate on B3.

	13. K to Q5
14. B to K3 (ch)	14. K to K4
15. R × B	15. P to B3

There is not much that is better.

16. R to KB sq	

Again threatening mate.

	16. P to KKt3
17. P to KKt3	17. Q × KtP (ch)

Black has no good move if 17. . . . Q to Kt5. 18. P to B3 (threatening mate by B to Q4), P to B4 (forced) 19. B to B4 (ch), and mate next move.

18. P × Q	18. P × Kt
19. B × QP, and mate next move by P to Q4.	

Our Whist Column.

BY W. MONTAGU GATTIE.

THIS column is addressed to two classes of readers—those who are already familiar with the principles of scientific whist, and those who are desirous of learning them. With the double purpose of interesting players of experience, and of affording instruction to beginners, we commence in this number of KNOWLEDGE a new series of "hands," which will be selected, when possible, from actual play, either in illustration of some general maxim in the theory of the game or as examples of brilliant combination.

We propose to offer a few criticisms on each hand, directing attention to its salient features, and the competent player need read no further; but we shall append, for the information of the student, a detailed explanation of the play and the inferences to be drawn from it. We hope by this means to give the novice the same information as he would derive from carefully going through the hand with a practised player (at once the best and the most agreeable way of learning); and we shall be fortunate if we are thus enabled to make the study of the game more attractive, and so to further in any degree the object which the late Mr. Proctor had principally in view in his articles under the *sobriquet* of "Five of Clubs," namely, that of diffusing a general knowledge of real whist, as distinguished from "Bumblepuppy."

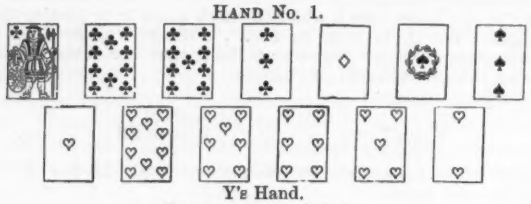
It is true that every one cannot be a Hoyle or a Clay. But there is no real reason why ninety-nine out of every hundred people who now sit down to a game which they call whist, but which, for any skill there is in it, might almost as well be "Beggar-my-neighbour," should not acquire in a short time an intelligent acquaintance with a very charming and intellectual recreation.

Our whist column will also be open for the discussion of moot points of law and custom, or debatable questions of correct play; and we shall publish occasional articles on theoretical and other matters of current interest.

The following hand is intended chiefly to illustrate the important principle of abandoning the command of, or "unblocking," a partner's suit. The student will observe, on referring to the hands given at the end of the play, that Z held very bad cards; and, in fact, he did not make a single trick. Yet it depended entirely on his play at the critical moment whether he and his partner, or their adversaries, won the rubber.

XUM

HAND No. 1.



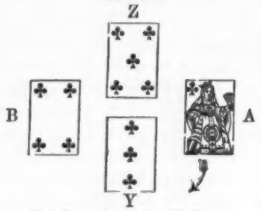
Y's Hand.

Score—A B, 2; Y Z, 4.
Z turns up the 5 of Clubs.

NOTE.—A and B are partners against Y and Z. A has the lead, Z is the dealer. The leader's card in each trick is indicated by an arrow.

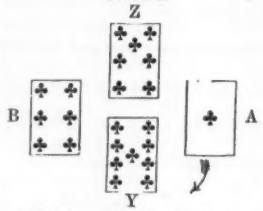
The notes appended to the tricks are supposed to be made *during the play* by the player whose hand is exposed. General remarks on the play follow at the end of the hand.

Trick 1.



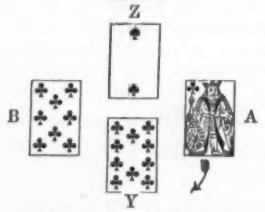
Tricks—A B, 1; Y Z, 0.

Trick 2.



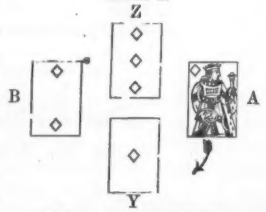
Tricks—A B, 2; Y Z, 0.

Trick 3.



Tricks—A B, 3; Y Z, 0.

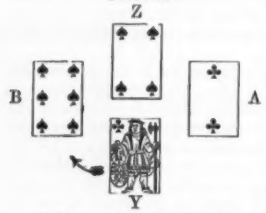
Trick 4.



Tricks—A B, 3; Y Z, 1.

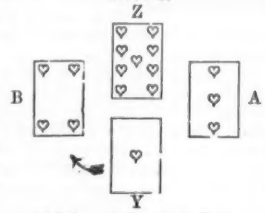
NOTE.—*Trick* 3. The Knave of trumps is marked in Y's own hand, and the deuce in A's hand; i.e. the command of the trump suit is declared to be with Y Z. Therefore, Z being a good player, Y is morally certain that he has discarded from his weakest suit, so that he can scarcely have more than two spades left.

Trick 5.



Tricks—A B, 3; Y Z, 2.

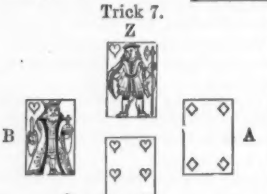
Trick 6.



Tricks—A B, 3; Y Z, 3.

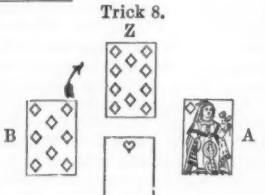
NOTE.—*Trick* 5. Z's discard confirms the inference drawn at trick 3; B's discard shows that spades is his best protected suit. *Trick* 6. Having six hearts and a card of re-entry, Y leads the ace so as to insure two rounds. [Nevertheless, we think the 6 (the ante-penultimate) was the proper lead.]

Trick 7.



Tricks—A B, 4; Y Z, 3.

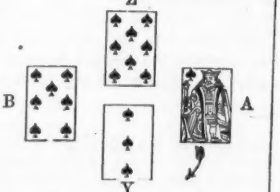
Trick 8.



Tricks—A B, 5; Y Z, 3.

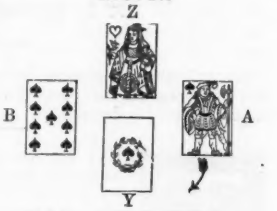
NOTE.—*Trick* 7. The Queen of Hearts is marked in Z's hand, and the 8 in B's. It is almost certain from A's discard that he has at least three diamonds left. *Trick* 8. Z has the Knave of Diamonds, and probably two others (see the note to trick 3); A has the 9 guarded. Y of course discards a heart in preference to blanking his Ace of Spades.

Trick 9.



Tricks—A B, 6; Y Z, 3.

Trick 10.



Tricks—A B, 6; Y Z, 4.

NOTE.—*Trick* 9. Y passes the King, so that his partner may have an opportunity on the next round of discarding the Queen of Hearts. If Y wins the King, Z will make the Queen of Hearts and the Knave of Diamonds, and will then have to lead a losing diamond, and A B, getting in, will make the odd trick in spades.

Tricks 11 to 13. Y makes his three hearts, and

Y Z SCORE THE ODD TRICK AND WIN THE GAME.

A's Hand.	B's Hand	Y's Hand.	Z's Hand.
C.—A, K, Q, 2	C.—8, 6, 4	C.—Kn, 10, 9, 3	C—7, 5
D.—K, Q, 9, 5, 4	D.—8, 2	D.—A	D.—Kn, 10, 7, 6, 3
S.—K, Kn, 5	S.—Q, 10, 9, 7, 6	S.—A, 3	S.—8, 4, 2
H.—3	H.—K, 8, 4	H.—A, 10, 7, 6, 5, 2	H.—Q, Kn, 9

REMARKS.—*Trick* 1. A's lead of trumps may be considered somewhat rash, as his suit is not established, and he is very weak in hearts; but we think it quite defensible, especially as the adversaries are four up.—*Trick* 3. But here, seeing that B has not "echoed," it would certainly have been more prudent to open the diamonds, instead of going on with trumps; A, however, hoped to bring down the remaining trumps at one blow. Z places the Knave of trumps with his partner, since B has not echoed, and he therefore rightly discards from his weakest suit.—*Trick* 4. "Cavendish," in A's place, would lead the Queen; we are not yet converted to acceptance of this new dogma.—*Trick* 7. B having shown strength in spades (Trick 5), we think A plays correctly in holding up his three spades, so as to assist B as much as possible, since there seems more chance of making game in that suit than in diamonds.—*Trick* 8. Some players would condemn Z's play in putting on the 10, on the ground that A would not dare to finesse against two cards. We, however, have seen many games lost in this way.—*Trick* 10. We have given the hand from Y's point of view in order that the *coup* at Trick 9 might be exhibited as clearly as possible; but Z's play at this point also deserves commendation. It requires some nerve to discard the Queen of Hearts, for he does not know whether the 10 is with Y or B; but he sees that, if he retains the Queen, his side can only make six tricks (the Queen of Spades being clearly with B), and he therefore takes the only chance of saving, and winning, the game.

We are compelled, for lack of space, to postpone the elementary explanation of this hand till next month.

CONTENTS OF No. 38.

	PAGE
Mud and Continents. By Grant Allen	25
Protoplasm a Builder. By Henry J. Slack, F.G.S., F.R.M.S.	26
On the Universal Action of Gravity. By the late R. A. Proctor	27
Footprints of Prehistoric Man	28
Prehistoric Metallurgy. By W. Mattieu Williams	30
Common Salt. By George McGowan, Ph.D.	31
Old Museums. I. The Ashmolean, Oxford	33
The Lick Observatory	34
On Some Strange Feats of Calculating Boys. By the late R. A. Proctor	37
The Jackal. By Dr. Robert F. Hutchinson	39
Notes	40
Letters	42
How Comets come to us	42
The Unknown Horn of Africa. By Edw. Clodd	43
Sir Wm. Siemens. By Wm. Lant Carpenter	45
Reviews	46
The Face of the Sky for December. By Herbert Sadler, F.R.A.S.	47
Our Chess Column. By "Mephisto"	48

TERMS OF SUBSCRIPTION.

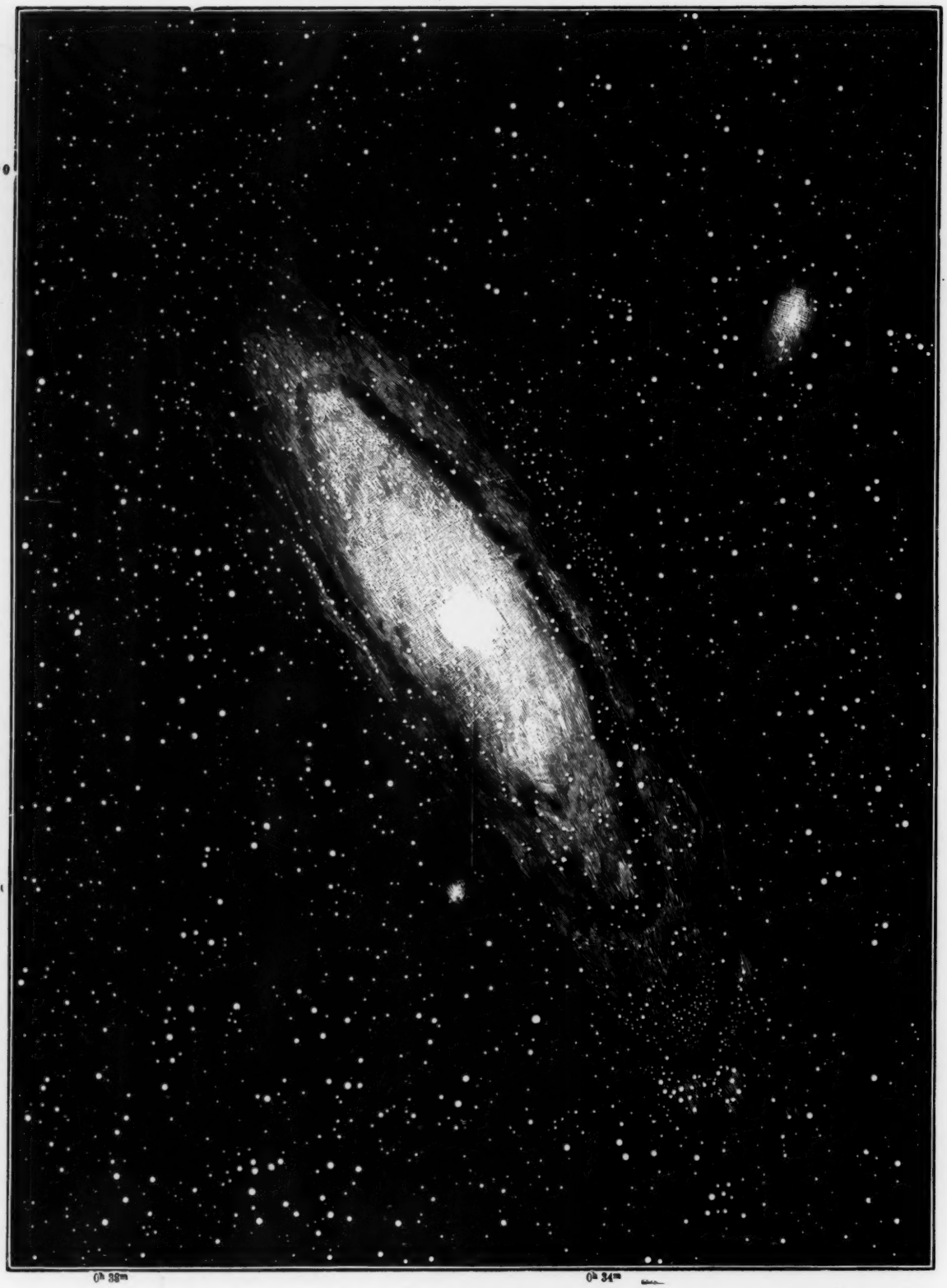
"KNOWLEDGE" as a Monthly Magazine cannot be registered as a Newspaper for transmission abroad. The Terms of Subscription per annum are therefore altered as follows to the Countries named:

	s.	d.
To West Indies and South America	9	0
To the East Indies, China, &c.	10	8
To South Africa	12	0
To Australia, New Zealand, &c.	14	0

To any address in the United Kingdom, the Continent, Canada, United States, and Egypt, the Subscription is 7s. 6d., as heretofore.

Communications for the Editor and Books for Review should be addressed Editor of "KNOWLEDGE," care of J. MALABY, 67 Chancery Lane, W.C.

XUM



GREAT NEBULA IN ANDROMEDA.

From an Original Negative taken by MR. ISAAC ROBERTS, F.R.A.S., *December* 29, 1888, *with an Exposure of Four Hours.*